MAPPING AND MATCHING RESOURCE UTILISATION AND RESPONSE PATTERNS IN FURTHER AND HIGHER EDUCATION

by

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C O N T E N T S

VOLUME I

"Tracing the Efficient Frontier in British Universities: A Discussion Paper"
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APPENDIX A

TIMETABLE AND STUDENT RECORD DATA

1972/3 and 1973/4

LANCHESTER - LOUGHBOROUGH

Tables 1 and 2 provide details of the numbers of students enrolled on courses included in the survey. Sandwich students who spent the whole of the relevant academic year out of college on industrial/ professional training are omitted. The ratio of sandwich to full-time students fell slightly but sandwich students still accounted for over 59% of the undergraduate population (Art and Design excepted) in both institutions. At both Lanchester and Loughborough the proportion of engineering and science students declined and the proportion of social and business studies students grew. Nevertheless in 1973/74 Loughborough remained predominantly (56%) a technology and engineering university.

TABLE 1

ENROLMENTS TO COURSES INCLUDED IN STUDY

LANCHESTER

Discipline Years:	1972/73 1	2	3	4	Total	%	1973/74 1	2	3	4	Total	%
SANDWICH												
Engineering	270	234	212	-	716	31.1	287	197	196	-	680	30.5
Science	72	60	49	-	181	7.8	67	47	47	-	161	7.2
Social Studies	133	130	127	8	398	17.3	152	116	122	13	403	18.1
Urban Planning	24	23	19	21	87	3.8	17	20	23	17	77	3.5
TOTAL	499	447	407	29	1382	60.0	523	380	30	30	1321	59.3
FULL-TIME												
Science	150	103	103	-	361	15.7	123	90	88	-	301	13.5
Social Studies	182	147	129	-	458	19.9	209	149	142	-	500	22.4
Languages	38	33	30	-	101	4.4	53	22	31	-	106	4.8
TOTAL	370	283	267	-	920	40.0	385	261	261	-	907	40.7
OVERALL	869	730	674	29	2302	100.0	908	641	649	30	2228	100.0

TABLE 2

ENROLMENT TO COURSES INCLUDED IN PROJECT STUDY

LOUGHBOROUGH

Discipline	Years: 1	2	3	Total	%	1	2	3	Total	%
SANDWICH										
Education	22	7	2	31	1.2	24	19	4	47	1.3
Engineering	549	313	257	1119	44.3	534	322	249	1105	43.0
Science	87	84	64	235	9.3	75	79	74	228	8.9
Social Studies	72	24	29	123	5.0	66	59	24	149	5.8
TOTAL	730	428	352	1510	59.8	699	479	351	1529	59.6
FULL-TIME										
Engineering	148	100	94	342	13.5	135	127	76	388	13.2
Science	127	108	97	332	13.1	99	106	91	296	11.5
Social Studies	103	56	33	192	7.6	81	96	50	227	8.8
Librarianship	29	21	15	65	2.6	53	28	19	100	3.9
Languages	39	19	27	85	3.4	27	33	17	77	3.0
TOTAL	446	304	266	1016	40.2	395	390	253	1038	40.4
OVERALL	1176	732	618	2526	100.0	1094	869	604	2567	100.0

The Timetable Analysis

Table 3 sets out some timetable statistics for both institutions. Over the normal three year undergraduate cycle there was a fall in the average students' tuition load from 1931 hours to 1900 hours at Lanchester, and from 1612 hours to 1571 hours at Loughborough. This change may be explained by the increased proportion of social and business studies in the discipline mix. The ratio of allocated meetings to meetings was much higher and the average group size ("students" and "institution's") remained lower at Lanchester in both years. Consequently the index of tuition demands did not vary a great deal over the years and remained more favourable to Loughborough:-

$$\text{index of undergraduate tuition demands} = \frac{\text{Allocated Meetings}}{\text{Enrolments}}$$

	Lanchester		Loughborough	
Years	1972/73	1973/74	1972/73	1973/74
1	48	45	21	23
2	69	70	31	30
3	75	77	31	32
4	64	45	-	-
Over normal 3 year cycle	63	62	27	28

TABLE 3

SOME TIMETABLE STATISTICS

	1972/73				1973/74			
Years:	1	2	3	4	1	2	3	4
Lanchester								
Students' Tuition Load (HRS)	655	692	584	378	643	687	570	350
Meetings (HRS)	42,459	51,672	51,984	1,864	42,607	46,496	51,955	1,349
Allocated Meetings (HRS)	40,794	50,349	50,473	1,864	40,855	44,095	49,794	1,349
Students' Average Group Size	31	20	18	16	33	18	16	13
(Standard Deviation)	(27)	(22)	(23)	(8)	(26)	(15)	(13)	(5)
Institution's Average Group Size	14	10	8	6	14	10	7	8
(Standard Deviation)	(16)	(10)	(9)	(8)	(16)	(9)	(8)	(6)
Loughborough								
Students' Tuition Load (HRS)	578	593	441	-	589	565	417	-
Meetings (HRS)	43,368	41,046	31,054	-	41,837	42,991	30,782	-
Allocated Meetings (HRS)	20,443	22,623	19,352	-	20,414	26,105	19,190	-
Students' Average Group Size	67	46	29	-	56	45	25	-
(Standard Deviation)	(62)	(29)	(22)	-	(48)	(12)	(23)	-
Institution's Average Group Size	27	19	14	-	26	19	13	-
(Standard Deviation)	(33)	(23)	(14)	-	(28)	(22)	(13)	-

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Table 4 compares the frequency distribution of average students' group sizes. Over the three year undergraduate cycle the most frequent group size for the Lanchester student was 6 - 10 in both 1972/73 and 1973/74 compared with 21 - 30 for the Loughborough student. In both years the range of group sizes experienced by the Loughborough undergraduate was wider.

Table 5 gives the frequency distribution of demand for teaching space. Again the pattern has not changed in 1973/74. In both years about 20% of the demand at Lanchester was for individual tutorials compared with about 6% at Loughborough. At the other end of the group size distribution about 12% of the demand at Loughborough was for groups greater than 40 whilst at Lanchester only about 3% of the demand was for groups of the size.

The institution's average group size (standard deviation) in specialist space was as follows:-

	Lanchester		Loughborough	
Years	1972/73	1973/73	1972/73	1973/74
1	13(8)	14(11)	22(12)	20(10)
2	9(6)	9(4)	14(9)	8(8)
3	6(5)	6(5)	11(6)	11(5)
4	21(0)	17(0)		

TABLE 4

FREQUENCY DISTRIBUTION OF AVERAGE STUDENTS' GROUP SIZES (HRS)

Group Sizes	1972/73 Years: 1	2	3	4	1973/74 1	2	3	4
LANCHESTER								
1	10	10	18	39	8	10	17	10
2-5	26	37	78	15	13	51	81	53
6-10	100	196	166	55	96	201	152	77
11-15	135	181	95	-	134	115	131	-
16-20	60	90	75	-	46	96	39	209
21-30	74	47	72	267	95	104	59	-
31-40	76	63	26	-	32	32	58	-
41-60	66	43	42	-	136	58	29	-
61-80	56	13	-	-	24	16	-	-
81-100	37	-	-	-	26	-	-	-
101-125	8	-	-	-	29	-	-	-
126-150	-	-	-	-	-	-	-	-
151-175	-	-	-	-	-	-	-	-
176-200	-	7	7	-	-	-	-	-
200+	-	-	-	-	-	-	-	-
LOUGHBOROUGH								
1	-	-	5	-	-	-	5	-
2-5	7	19	18	-	7	21	18	-
6-10	31	50	45	-	29	57	63	-
11-15	64	71	64	-	57	56	55	-
16-20	53	73	73	-	46	49	59	-
21-30	77	59	76	-	112	81	104	-
31-40	24	69	54	-	42	34	53	-
41-60	85	90	66	-	66	93	24	-
61-80	47	96	34	-	74	84	30	-
81-100	52	14	-	-	50	43	-	-
101-125	40	3	-	-	27	15	-	-
126-150	25	15	-	-	39	8	-	-
151-175	10	7	-	-	25	11	-	-
176-200	39	13	-	-	6	1	-	-
200+	17	6	1	-	2	4	1	-

TABLE 5

FREQUENCY DEMAND FOR TEACHING SPACE (HRS)

Group Size	1972/73	Cum.%	1973/74	Cum.%
LANCHESTER				
1	29,650	20.6	26,590	19.5
2-5	24,755	37.9	25,313	38.1
6-10	41,682	66.9	39,085	66.8
11-15	24,170	83.8	22.754	83.6
16-20	9,409	90.4	7,411	89.0
21-30	6,534	95.0	7,778	94.7
31-40	3,643	97.5	2,621	96.7
41-60	2,302	99.1	3,549	99.3
61-80	839	99.7	479	99.6
81-100	375	99.3	255	99.8
101-125	60	99.9	261	100.0
126-150	-	99.9	-	100.0
151-175	-	99.9	-	100.0
176-200	53	99.9	-	100.0
200+	3	100.0	-	100.0
LOUGHBOROUGH				
1	3,894	6.2	3,828	5.8
2-5	9,619	21.6	10,511	21.8
6-10	11,919	40.7	13,802	42.8
11-15	11,686	59.4	10,483	58.7
16-20	8,434	72.9	6,821	69.1
21-30	6,462	83.2	9,940	84.2
31-40	3,030	88.1	2,958	88.7
41-60	3,821	94.2	3,240	93.6
61-80	1,908	97.2	2,312	97.1
81-100	674	98.3	925	98.6
101-125	369	98.9	356	99.1
126-150	256	99.3	324	99.6
151-175	88	99.4	206	99.9
176-200	262	99.8	38	99.95
200+	107	100.0	28	100.0

The Student Record

Tables 6 and 7 summarise the student record for 1972/73 and 1973/74. The A-level grades have been calculated on the normal UCCA basis of A=5, B=4, C=3, D=2 and E=1. The average A level grade at Loughborough was about three quarters of a grade above that at Lanchester in both years. Apart from the 1972/73 first year results at Lanchester the pass, failure and 'not taken' rates were similar in both institutions in both years. The mean marks and their standard deviations were also similar in both years. The correlation of A level grades with subsequent degree performance is consistently higher at Loughborough but at best explains only about 12% of subsequent degree performance. The correlation between one years and the preceding year's examination results is higher in both years at Loughborough. Comparison of mean ONC/OND marks and degree examinations resulted in the following correlations:

Year	1972/73		1973/74		1972/73		1973/74	
	N	r	N	r	N	r	N	r
1	69	+.40	75	+.33	93	+.44	95	+.38
2	75	+.29	56	+.33	66	+.37	68	+.10
3	50	+.31	67	+.17	65	+.27	71	+.05

TABLE 6

SOME UNDERGRADUATE STATISTICS

LANCHESTER

	1972/73				1973/74			
Years:	1	2	3	4	1	2	3	4
A Level Entry								
Mean	2.13	2.21	2.24	2.83	2.13	2.13	2.24	2.70
(Standard Deviation)	(0.82)	(0.83)	(0.81)	(0.62)	(0.83)	(0.78)	(0.79)	(0.83)
% Enrolments								
Pass	60	88	97	86	70	87	96	93
To Ordinary	11	1	0	0	10	2	0	0
	71	89	97	86	80	89	96	93
Fail	22	9	3	3	12	10	3	3
Not taken	7	2	0	10	7	2	1	3
	100	100	100	100	100	100	100	100
Mean Marks	51.8	55.3	50.4	60.4	52.8	54.1	56.0	57.3
(Standard Deviation)	(10.2)	(8.2)	(7.5)	(5.1)	(10.0)	(7.8)	(7.6)	(7.0)
Correlations								
Results v A Levels	+.15	+.05	+.14	-.24	+.20	+.05	+.07	-.07
2 v 1		+.46				+.54		
3 v 2			+.68				+.61	
4 v 3				+.53				+.43

TABLE 7

SOME UNDERGRADUATE STATISTICS

LOUGHBOROUGH

	1972/73			1973/74		
Years	1	2	3	1	2	3
A Level Entry						
Mean	2.90	2.93	2.99	2.92	2.93	2.90
(Standard Deviation)	(0.79)	(0.82)	(0.82)	(0.88)	(0.78)	(0.80)
% Enrolments						
Pass	82	85	95	83	87	96
To Ordinary	4	4	0	2	3	0
	86	89	95	85	90	96
Fail	6	3	2	8	4	2
	100	100	100	100	100	100
Mean Marks	53.3	54.3	58.2	55.8	54.9	58.6
(Standard Deviation)	(10.8)	(10.9)	(9.7)	(11.7)	(10.7)	(9.2)
Correlations						
Results v A Levels	+.29	+.27	+.15	+.35	+.25	+.14
2 v 1		+.63			+.62	
3 V 2			+.71			+.65

TABLE 8

FIRST SALARY DATA FOR GRADUATES AND CORRELATION WITH FINAL MARK

Discipline	N	MEAN £	STANDARD DEVIATION	r	N	MEAN £	STANDARD DEVIATION	r
LANCHESTER								
Engineering	56	1778	(286)	-.10				
Science	32	1523	(364)	+.13				
Social Studies	51	1696	(359)	-.01		DATA NOT AVAILABLE		
Languages	6	1486	(302)	+.47				
All	145	1681	(347)	+.03				
LOUGHBOROUGH								
Engineering	190	1725	(388)	+.17	157	2039	(586)	+.08
Science	83	1503	(279)	+.02	86	1772	(282)	+.08
Social Studies	26	1756	(346)	+.55	22	1761	(248)	-.35
Librarianship	11	1466	(166)	+.14	14	1709	(158)	-.11
Languages	8	1396	(102)	+.07	5	1870	(100)	-.74
All	318	1654	(365)	+.19	285	1916	(488)	+.10

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Discipline Group	Illustrative departments falling within group
1. Education	
2. Health	Pharmacy, other departments allied to medicine and health.
3. Technology	Aeronautical, chemical, civil, electrical, mechanical, and producation engineering; mining, metalurgy, building, surveying and general engineering. General technology and manufacture e.g. textile technology, printing and book production.
4. Agriculture	
5. Science and Applied Sciences	Biology, botany, zoology and combinations of biological sciences, Mathematics, physics, chemistry, geology.
6. Social (administrative and business) studies	Management studies, economics, geography, government and public administration, law, sociology, liberal studies, accountancy.
7a. Vocational - architecture and town and country planning	Architecture, town and country planning
7b. Vocational - other	Catering, institutional management, home economics, Librarianship, nautical studies, transport.
8. Languages (literature and area) studies	
9. Arts (other than Languages)	History, archaeology, philosophy.
10. Art and Design	Art and Design, drama, music.

KEY TO GROUP SIZES

1	1
2	2-5
3	6-10
4	11-15
5	16-20
6	21-30
7	31-40
8	41-60
9	61-80
10	81-100
11	101-125
12	126-150
13	151-175
14	176-200
15	201+

TABLE 9

YEAR 1 ENROLMENTS, STUDENT LOAD, MEETINGS, ALLOCATABLE MEETINGS, GROUP SIZES BY DISCIPLINE

1972/73

DISCIPLINE	ENROLMENTS	STUDENT LOAD (HRS)	MEETINGS (HRS)	ALLOCATABLE MEETINGS (HRS)	STUDENTS' AVERAGE GROUP SIZE (STANDARD DEVIATION)	INSTITUTIONS' AVERAGE GROUP SIZE (STANDARD DEVIATION)
LANCHESTER						
3	246	796	16741	16625	21.2 (14.9)	11.8 (10.5)
5	222	789	11750	11750	36.2 (32.6)	14.9 (17.8)
6	315	468	11690	10646	39.2 (31.5)	13.9 (18.7)
7a	24	510	740	740	23.6 (3.2)	16.5 (10.8)
8	33	589	1529	1023	36.1 (7.3)	21.9 (17.6)
TOTAL	845	654	42459	40784	31.4 (27.3)	13.6 (15.5)
LOUGHBOROUGH						
1	22	490	1590	573	53.0 (48.8)	18.7 (25.2)
3	485	620	17666	10391	70.9 (64.8)	28.9 (34.8)
5	214	582	14357	4469	59.4 (49.5)	27.8 (29.5)
6	174	498	10255	2802	77.5 (54.7)	30.8 (37.9)
7b	29	567	1390	1180	27.7 (41.0)	13.9 (13.8)
8	39	455	1110	1028	45.5 (57.1)	17.2 (22.0)
TOTAL	963	578	46363	20443	66.9 (61.9)	27.2 (32.8)

1973/74

DISCIPLINE	ENROLMENTS	STUDENT LOAD (HRS)	MEETINGS (HRS)	ALLOCATABLE MEETINGS (HRS)	STUDENTS' AVERAGE GROUP SIZE (STANDARD DEVIATION)	INSTITUTIONS' AVERAGE GROUP SIZE (STANDARD DEVIATION)
LANCHESTER						
3	287	764	17959	17868	21.6 (14.7)	12.3 (10.7)
5	190	807	9289	9289	32.0 (22.6)	16.5 (16.0)
6	361	476	13010	11845	45.6 (36.2)	14.5 (21.3)
7a	17	510	670	670	16.7 (2.2)	12.9 (7.0)
8	53	589	1679	1182	50.2 (10.5)	26.4 (25.1)
TOTAL	908	643	42607	40855	32.9 (25.5)	14.3 (16.3)
LOUGHBOROUGH						
1	24	489	1590	589	46.2 (40.14)	19.8 (22.8)
3	482	627	17186	10651	62.8 (62.4)	28.3 (31.2)
5	174	587	13725	4647	38.5 (28.7)	21.9 (19.1)
6	146	500	6726	2554	65.9 (42.1)	28.5 (32.6)
7b	53	557	1530	1202	35.6 (35.1)	24.6 (16.4)
8	22	530	1080	769	49.9 (56.1)	15.1 (22.9)
TOTAL	901	589	41837	20414	56.4 (47.7)	25.9 (28.1)

TABLE 10

YEAR 2 ENROLMENTS, STUDENT LOAD, MEETINGS, ALLOCATABLE MEETINGS, GROUP SIZES BY DISCIPLINE

1972/73

DISCIPLINE	ENROLMENTS	STUDENT LOAD (HRS)	MEETINGS (HRS)	ALLOCATABLE MEETINGS (HRS)	STUDENTS' AVERAGE GROUP SIZE (STANDARD DEVIATION)	INSTITUTIONS' AVERAGE GROUP SIZE (STANDARD DEVIATION)
LANCHESTER						
3	234	831	22183	22183	11.6 (4.8)	8.8 (4.9)
5	163	941	15255	15255	14.5 (9.2)	10.1 (6.7)
6	277	453	12089	11214	36.1 (38.1)	11.2 (16.7)
7a	23	500	720	720	22.6 (3.1)	16.0 (10.3)
8	33	625	1425	977	31.4 (5.2)	21.1 (14.7)
TOTAL	730	692	51672	50349	19.6 (22.4)	10.0 (9.8)
LOUGHBOROUGH						
1	7	527	1185	397	37.4 (44.3)	9.1 (15.6)
3	413	632	18874	12751	54.8 (46.7)	20.4 (26.5)
5	192	599	8697	5470	36.7 (29.7)	20.8 (18.1)
6	80	435	9500	2294	29.2 (30.3)	15.1 (14.5)
7b	21	497	1710	974	15.8 (11.3)	10.7 (7.4)
8	19	480	1080	737	21.8 (17.4)	12.4 (10.8)
TOTAL	732	593	41046	22623	46.2 (28.5)	19.1 (22.7)

1973/74

DISCIPLINE	ENROLMENTS	STUDENT LOAD (HRS)	MEETINGS (HRS)	ALLOCATABLE MEETINGS (HRS)	STUDENTS' AVERAGE GROUP SIZE (STANDARD DEVIATION)	INSTITUTIONS' AVERAGE GROUP SIZE (STANDARD DEVIATION)
LANCHESTER						
3	197	844	17950	17950	13.9 (7.4)	9.3 (6.6)
5	124	972	13534	13534	13.8 (9.8)	8.9 (6.6)
6	265	457	12947	11077	28.7 (21.4)	10.9 (13.9)
7a	20	500	690	690	19.6 (2.7)	14.5 (8.6)
8	22	625	1375	844	21.4 (2.7)	16.3 (9.1)
TOTAL	628	687	46496	44095	18.4 (14.8)	9.8 (9.2)
LOUGHBOROUGH						
1	19	469	1575	602	34.9 (26.1)	14.7 (17.1)
3	448	618	19900	14032	52.4 (31.9)	19.7 (25.3)
5	185	576	8353	5600	35.03 (25.2)	19.0 (17.4)
6	155	417	10578	3531	40.9 (34.7)	18.2 (20.2)
7b	28	629	1475	1347	18.9 (18.6)	13.1 (8.7)
8	33	495	1110	991	35.1 (31.0)	16.5 (17.3)
TOTAL	868	565	42991	26105	45.0 (11.6)	18.8 (22.1)

TABLE 11

YEAR 3 ENROLMENTS, STUDENTS' LOAD, MEETINGS, ALLOCATABLE MEETINGS, GROUP SIZES BY DISCIPLINE

1972/73

DISCIPLINE	ENROLMENT	STUDENT LOAD (HRS)	MEETINGS (HRS)	ALLOCATABLE MEETINGS (HRS)	STUDENTS' AVERAGE GROUP SIZE (STANDARD DEVIATION)	INSTITUTIONS' AVERAGE GROUP SIZES (STANDARD DEVIATION)
LANCHESTER						
3	212	702	23293	23293	11.6 (7.7)	6.4 (5.8)
5	157	741	17062	17062	11.5 (7.9)	6.8 (5.6)
6	256	404	9599	8609	33.5 (38.0)	12.0 (16.1)
7a	19	480	660	660	18.6 (2.6)	13.8 (8.2)
8	30	520	1350	848	28.1 (5.3)	18.4 (13.4)
TOTAL	674	584	51964	50473	18.2 (22.7)	7.8 (9.0)
LOUGHBOROUGH						
1	2	100	120	30	18.5 (14.9)	6.4 (8.6)
3	351	433	13854	8848	35.2 (25.8)	17.2 (17.6)
5	161	507	9830	7048	20.9 (13.0)	11.6 (10.4)
6	62	373	5720	1993	19.8 (10.9)	11.6 (9.7)
7a	15	332	720	720	8.3 (3.5)	6.9 (3.0)
8	27	390	810	713	23.3 (13.7)	14.7 (11.2)
TOTAL	618	441	31054	19352	28.6 (22.3)	14.1 (14.3)

1973/74

DISCIPLINE	ENROLMENT	STUDENT LOAD (HRS)	MEETINGS (HRS)	ALLOCATABLE MEETINGS (HRS)	STUDENTS' AVERAGE GROUP SIZE (STANDARD DEVIATION)	INSTITUTIONS' AVERAGE GROUP SIZE (STANDARD DEVIATION)
LANCHESTER						
3	191	695	23749	23749	9.02 (4.9)	5.6 (4.4)
5	135	743	15597	15597	10.4 (8.2)	6.4 (5.1)
6	264	409	10639	8929	25.8 (15.1)	12.09 (12.87)
7a	23	442	670	670	20.9 (3.2)	15.2 (9.3)
8	31	520	1300	849	29.3 (5.1)	19.0 (14.0)
TOTAL	644	570	51955	49794	15.6 (12.6)	7.4 (7.8)
LOUGHBOROUGH						
1	4	70	90	30	26.3 (26.2)	9.01 (12.2)
3	325	422	14086	9165	31.2 (29.1)	14.9 (15.6)
5	165	427	8456	6055	20.9 (10.2)	11.6 (10.4)
6	74	397	6665	2520	18.9 (9.4)	11.7 (9.2)
7b	19	360	720	720	9.5 (0.0)	9.5 (0.0)
8	17	450	765	699	14.4 (8.6)	10.9 (6.1)
TOTAL	604	417	30782	19190	25.8 (23.3)	13.1 (12.9)

TABLE 12

YEAR 4 ENROLMENTS, STUDENTS' LOAD, MEETINGS, ALLOCATABLE MEETINGS, GROUP SIZE BY DISCIPLINE

1972/73

DISCIPLINE	ENROLMENTS	STUDENTS' LOAD (HRS)	MEETINGS (HRS)	ALLOCATABLE MEETINGS (HRS)	STUDENTS' AVERAGE GROUP SIZE (STANDARD DEVIATION)	INSTITUTIONS' AVERAGE GROUP SIZE (STANDARD DEVIATION)
LANCHESTER						
3	-	-	-	-	-	-
5	-	-	-	-	-	-
6	8	308	759	759	5.4 (2.3)	3.3 (2.7)
7a	21	405	1105	1105	19.3 (5.6)	7.7 (9.4)
8	-	-	-	-	-	-
TOTAL	29	378	1864	1864	16.2 (7.7)	5.9 (7.8)

1973/74

DISCIPLINE	ENROLMENTS	STUDENTS' LOAD (HRS)	MEETINGS (HRS)	ALLOCATABLE MEETINGS (HRS)	STUDENTS' AVERAGE GROUP SIZE (STANDARD DEVIATION)	INSTITUTIONS' AVERAGE GROUP SIZE (STANDARD DEVIATION)
LANCHESTER						
3	-	-	-	-	-	-
5	-	-	-	-	-	-
6	13	311	809	809	7.3 (3.3)	5.0 (3.4)
7a	17	380	540	540	16.6 (2.6)	12.0 (7.4)
8	-	-	-	-	-	-
TOTAL	30	350	1349	1349	13.0 (5.4)	7.8 (6.4)

TABLE 13

YEAR 1 UNDERGRADUATE RESULTS BY DISCIPLINE

1972/73

DISCIPLINE	ENROL	PASS	TO ORD	FAIL	NOT TAKEN	MEAN MARK	STANDARD DEVIATION
LANCHESTER							
3	270	131 (0.49)	46 (0.17)	70 (0.26)	23 (0.08)	53.68	11.19
5	222	102 (0.46)	39 (0.18)	65 (0.29)	16 (0.07)	50.77	10.50
6	316	245 (0.78)	11 (0.03)	43 (0.14)	16 (0.05)	50.36	9.11
7a	24	21 (0.88)	0 (0.00)	2 (0.08)	1 (0.04)	58.09	4.09
8	38	24 (0.63)	0 (0.00)	8 (0.21)	6 (0.16)	52.66	8.53
TOTAL	860	523 (0.60)	96 (0.11)	188 (0.22)	62 (0.07)	51.79	10.19
LOUGHBOROUGH							
1	22	19 (0.86)	0 (0.00)	3 (0.14)	0 (0.00)	51.77	10.65
3	697	567 (0.81)	27 (0.04)	68 (0.10)	35 (0.06)	53.60	11.26
5	214	165 (0.77)	13 (0.06)	17 (0.08)	19 (0.09)	51.55	12.30
6	175	151 (0.86)	4 (0.02)	9 (0.05)	11 (0.06)	54.14	8.07
7b	29	28 (0.97)	0 (0.00)	1 (0.03)	0 (0.00)	55.55	6.68
8	39	34 (0.87)	0 (0.00)	5 (0.11)	0 (0.00)	53.34	5.23
TOTAL	1176	44 (0.04)	44 (0.04)	103 (0.09)	65 (0.06)	53.33	10.81

1973/74

DISCIPLINE	ENROL	PASS	TO ORD	FAIL	NOT TAKEN	MEAN MARK	STANDARD DEVIATION
LANCHESTER							
3	287	154 (.54)	46 (.20)	50 (.17)	27 (.09)	53.94	12.80
5	190	127 (.67)	33 (.17)	19 (.10)	11 (.06)	53.61	9.24
6	361	298 (.83)	5 (.01)	36 (.10)	22 (.06)	57.60	8.15
7a	17	17 (1.0)	0 (.00)	0 (.00)	0 (.00)	53.82	3.36
8	53	43 (.81)	0 (.00)	5 (.09)	5 (.09)	52.70	7.47
TOTAL	908	639 (.70)	94 (.10)	110 (.12)	65 (.07)	52.84	9.95
LOUGHBOROUGH							
1	24	22 (.92)	0 (.00)	1 (.04)	1 (.04)	54.87	10.06
3	669	532 (.80)	27 (.04)	59 (.09)	51 (.08)	55.96	12.71
5	174	154 (.89)	0 (.00)	13 (.07)	7 (.04)	54.54	12.37
6	147	126 (.86)	0 (.00)	5 (.03)	16 (.11)	55.64	6.94
7b	53	49 (.92)	0 (.00)	1 (.02)	3 (.06)	57.34	8.02
8	27	20 (.74)	0 (.00)	0 (.00)	7 (.26)	56.89	4.00
TOTAL	1094	903 (.83)	27 (.02)	79 (.07)	83 (.08)	55.75	11.71

TABLE 14

YEAR 2 UNDERGRADUATE RESULTS BY DISCIPLINE

1972/73

DISCIPLINE	ENROL	PASS	TO ORD	FAIL	NOT TAKEN	MEAN MARK	STANDARD DEVIATION
LANCHESTER							
3	234	195 (0.83)	3 (0.01)	35 (0.15)	1 (0.00)	56.56	9.26
5	163	136 (0.83)	3 (0.02)	20 (0.12)	4 (0.02)	55.66	9.66
6	277	259 (0.94)	1 (0.00)	13 (0.05)	4 (0.01)	54.15	6.38
7a	23	23 (1.00)	0 (0.00)	0 (0.00)	0 (0.00)	53.09	5.35
8	33	29 (0.88)	0 (0.00)	1 (0.03)	3 (0.09)	55.03	4.91
TOTAL	730	642 (0.88)	7 (0.01)	69 (0.09)	12 (0.02)	55.27	8.19
LOUGHBOROUGH							
1	7	5 (0.71)	0 (0.00)	1 (0.14)	1 (0.14)	51.67	5.59
3	413	341 (0.83)	26 (0.06)	40 (0.10)	6 (0.01)	54.75	11.36
5	192	170 (0.89)	0 (0.00)	16 (0.08)	6 (0.03)	53.22	11.46
6	80	71 (0.89)	0 (0.00)	5 (0.06)	4 (0.05)	54.38	8.29
7b	21	19 (0.90)	0 (0.00)	0 (0.00)	2 (0.10)	58.84	5.13
8	19	16 (0.84)	0 (0.00)	3 (0.16)	0 (0.00)	50.58	6.22
TOTAL	732	622 (0.85)	26 (0.04)	65 (0.09)	19 (0.03)	54.29	10.89

1973/74

DISCIPLINE	ENROL	PASS	TO ORD	FAIL	NOT TAKEN	MEAN MARK	STANDARD DEVIATION
LANCHESTER							
3	197	164 (.83)	6 (.03)	25 (.13)	2 (.01)	56.15	9.02
5	137	115 (.84)	4 (.03)	14 (.10)	4 (.03)	54.42	7.89
6	265	236 (.89)	0 (.00)	21 (.08)	8 (.03)	52.04	6.71
7a	20	19 (.95)	0 (.00)	1 (.05)	0 (.00)	56.33	3.52
8	22	21 (.95)	0 (.00)	1 (.05)	0 (.00)	55.76	3.98
TOTAL	641	555 (.87)	10 (.02)	62 (.10)	14 (.02)	54.09	7.84
LOUGHBOROUGH							
1	19	18 (.95)	0 (.00)	0 (.00)	1 (.05)	51.94	7.31
3	449	366 (.82)	26 (.06)	44 (.10)	13 (.03)	54.98	12.33
5	185	167 (.90)	1 (.01)	7 (.04)	10 (.05)	54.01	10.64
6	155	146 (.94)	0 (.00)	2 (.01)	7 (.05)	55.44	6.38
7b	28	26 (.93)	0 (.00)	0 (.00)	2 (.07)	57.69	5.76
8	33	32 (.97)	0 (.00)	0 (.00)	1 (.03)	56.06	3.37
TOTAL	869	755 (.87)	27 (.03)	53 (.06)	34 (.04)	54.93	10.65

TABLE 15

YEAR 3 UNDERGRADUATE RESULTS BY DISCIPLINE

1972/73

DISCIPLINE	ENROL	PASS	TO ORD	FAIL	NOT TAKEN	MEAN MARK	STANDARD DEVIATION
LANCHESTER							
3	212	208 (0.98)	0 (0.00)	4 (0.02)	0 (0.00)	62.41	7.52
5	157	148 (0.94)	0 (0.00)	9 (0.06)	0 (0.00)	57.88	8.36
6	256	250 (0.98)	0 (0.00)	4 (0.02)	2 (0.01)	55.69	5.88
7a	19	18 (0.95)	0 (0.00)	0 (0.00)	1 (0.05)	57.44	4.70
8	30	30 (1.00)	0 (0.00)	0 (0.00)	0 (0.00)	56.00	4.68
TOTAL	674	654 (.97)	0 (0.00)	17 (0.03)	3 (0.00)	58.40	7.47
LOUGHBOROUGH							
1	2	2 (1.00)	0 (0.00)	0 (0.00)	0 (0.00)	51.00	7.00
3	351	331 (0.94)	0 (0.00)	13 (0.04)	7 (0.02)	59.65	9.52
5	161	152 (0.94)	0 (0.00)	7 (0.04)	2 (0.01)	56.14	10.66
6	62	62 (0.98)	0 (0.00)	1 (0.02)	0 (0.00)	55.42	7.34
7b	15	15 (1.00)	0 (0.00)	0 (0.00)	0 (0.00)	61.93	9.30
8	27	27 (1.00)	0 (0.00)	0 (0.00)	0 (0.00)	55.56	5.82
TOTAL	618	589	0	21	9	58.15	9.89

1973/74

DISCIPLINE	ENROL	PASS	TO ORD	FAIL	NOT TAKEN	MEAN MARK	STANDARD DEVIATION
LANCHESTER							
3	196	190 (.97)	0 (.00)	4 (.02)	2 (.01)	60.53	7.36
5	135	125 (.93)	0 (.00)	8 (.06)	2 (.01)	55.06	7.79
6	264	255 (.97)	0 (.00)	9 (.03)	0 (.00)	53.21	6.51
7a	23	22 (.96)	0 (.00)	0 (.00)	1 (.04)	54.68	4.08
8	31	30 (.97)	0 (.00)	1 (.03)	0 (.00)	56.16	4.25
TOTAL	649	622 (.96)	0 (.00)	22 (.03)	5 (.01)	55.99	7.57
LOUGHBOROUGH							
1	4	4 (1.00)	0 (.00)	0 (.00)	0 (.00)	49.50	2.50
3	325	309 (.95)	1 (.00)	9 (.03)	6 (.02)	59.58	10.06
5	165	162 (.98)	0 (.00)	1 (.01)	2 (.01)	57.34	8.89
6	74	70 (.95)	0 (.00)	1 (.01)	3 (.04)	56.83	6.66
7b	19	19 (1.00)	0 (.00)	0 (.00)	0 (.00)	62.26	3.88
8	17	17 (1.00)	0 (.00)	0 (.00)	0 (.00)	55.18	4.47
TOTAL	604	581 (.96)	1 (.00)	11 (.02)	11 (.02)	58.56	9.23

TABLE 16

YEAR 4 UNDERGRADUATE RESULTS BY DISCIPLINE

1972/73

DISCIPLINE	ENROL	PASS	TO ORD	FAIL	NOT TAKEN	MEAN MARK	STANDARD DEVIATION
LANCHESTER							
3	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-
6	8	8 (1.00)	0 (0.00)	0 (0.00)	0 (0.00)	64.00	4.72
7a	21	17 (0.81)	0 (0.00)	1 (0.05)	3 (0.14)	58.78	4.46
8	-	-	-	-	-	-	-
TOTAL	29	25 (0.86)	0 (0.00)	1 (0.03)	3 (0.10)	60.38	5.14

1973/74

DISCIPLINE	ENROL	PASS	TO ORD	FAIL	NOT TAKEN	MEAN MARK	STANDARD DEVIATION
LANCHESTER							
3	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-
6	13	13 (1.0)	0 (0.00)	0 (0.00)	0 (0.00)	58.62	4.64
7a	17	15 (.88)	0 (0.00)	1 (.06)	1 (.06)	56.31	0.30
8	-	-	-	-	-	-	-
TOTAL	30	28 (.93)	0 (0.00)	1 (.03)	1 (.03)	57.34	7.00

2

LOUGHBOROUGH - FREQUENCY DISTRIBUTION (HOURS/ANNUM) OF STUDENTS' GROUP SIZES BY DISCIPLINE 1972/73

DISCIPLINE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PART A															
1	4	0	56	90	0	104	0	70	0	33	38	19	19	1	3
3	0	6	27	53	71	78	25	83	75	31	49	16	1	72	22
5	0	19	0	47	48	143	42	68	29	109	3	45	0	4	18
6	0	0	53	28	11	22	12	146	16	41	71	35	25	13	11
7b	0	0	166	270	64	0	1	1	0	0	20	20	20	0	0
8	0	0	35	240	60	0	0	0	0	60	0	0	60	0	0
ALL	0	7	31	64	53	77	24	85	47	52	40	25	10	39	17
PART B															
1	0	112	98	7	105	32	0	28	17	100	8	0	0	11	5
3	0	24	32	49	86	72	59	79	128	21	6	25	12	21	10
5	0	2	50	121	45	60	76	139	90	4	0	0	0	3	3
6	0	19	87	38	92	25	101	52	0	0	0	7	4	5	0
7b	0	50	45	243	88	0	69	21	0	0	0	0	0	0	0
8	0	30	270	0	0	0	90	0	0	0	0	0	0	0	0
ALL	0	19	50	71	73	59	69	90	96	14	3	15	7	13	6
PART C															
1	0	25	20	5	0	30	0	30	0	0	0	0	0	0	0
3	3	11	33	44	47	67	62	95	59	0	0	0	0	0	2
5	11	15	43	123	151	60	66	28	1	0	0	0	0	0	0
6	4	44	53	28	70	139	12	20	0	0	0	0	0	0	0
7b	0	150	82	100	0	0	0	0	0	0	0	0	0	0	0
8	0	0	122	27	0	180	0	60	0	0	0	0	0	0	0
ALL	5	18	45	64	73	73	54	68	34	0	0	0	0	0	1

LOUGHBOROUGH - FREQUENCY DISTRIBUTION (HOURS/ANNUM) OF STUDENTS' GROUP SIZES BY DISCIPLINE 1973/74

DISCIPLINE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PART A															
1	3	0	60	81	15	92	64	4	75	22	22	22	22	0	0
3	0	6	26	75	40	83	52	94	50	69	24	57	29	12	4
5	0	20	4	33	54	218	36	60	109	2	37	7	0	0	0
6	0	0	71	0	41	12	35	23	150	64	33	33	33	0	0
7b	0	0	14	0	120	363	0	0	0	0	18	6	33	0	0
8	0	5	15	330	0	0	0	0	0	60	0	60	60	0	0
ALL	0	7	29	57	46	112	42	66	74	50	27	39	25	6	2
PART B															
1	6	1	64	69	95	0	64	22	123	16	3	0	0	0	0
3	0	30	35	45	40	96	44	91	104	56	25	15	17	3	8
5	0	21	77	12	105	109	16	118	99	1	11	1	1	0	0
6	1	7	71	52	19	41	36	93	31	48	0	1	9	0	2
7b	0	0	215	330	0	10	0	21	32	19	0	0	0	0	0
8	0	0	30	240	0	30	0	90	0	105	0	0	0	0	0
ALL	0	21	57	56	49	81	34	93	84	43	15	8	11	1	4
PART C															
1	0	20	5	20	5	0	0	0	20	0	0	0	0	0	0
3	3	18	57	35	58	114	34	40	56	0	0	0	0	0	3
5	10	20	12	115	91	75	8	0	0	0	0	0	0	0	0
6	2	26	93	34	6	180	63	0	0	0	0	0	0	0	0
7b	0	0	360	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	270	0	90	30	60	0	0	0	0	0	0	0	0
ALL	5	18	63	55	59	104	53	24	30	0	0	0	0	0	1

LANCHESTER - FREQUENCY DISTRIBUTION (HOURS/ANNUM) OF STUDENTS' GROUPS SIZES BY DISCIPLINE 1972/73

DISCIPLINE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PART A															
3	10	75	103	196	150	71	100	72	0	0	0	0	0	0	0
5	10	15	103	180	43	138	74	46	71	72	33	0	0	0	0
6	10	1	116	78	13	9	0	85	100	50	0	0	0	0	0
7a	10	0	0	0	0	500	0	0	0	0	0	0	0	0	0
8	10	0	0	30	0	0	549	0	0	0	0	0	0	0	0
ALL	10	26	100	135	60	74	76	66	56	37	8	0	0	0	0
PART B															
3	10	75	314	237	145	48	0	0	0	0	0	0	0	0	0
5	10	33	285	357	136	16	81	18	0	0	0	0	0	0	0
6	11	11	15	88	66	35	25	53	104	36	0	0	0	20	0
7a	10	0	0	0	490	0	0	0	0	0	0	0	0	0	0
8	10	0	0	0	0	60	535	0	0	0	0	0	0	0	0
ALL	10	37	196	181	90	47	63	43	13	0	0	0	0	7	0
PART C															
3	26	139	212	134	92	56	38	0	0	0	0	0	0	0	0
5	22	131	267	146	106	49	0	0	0	0	0	0	0	0	0
6	10	8	98	49	14	62	38	101	0	0	0	0	0	20	0
7a	10	0	0	0	470	0	0	0	0	0	0	0	0	0	0
8	10	0	0	0	60	0	450	0	0	0	0	0	0	0	0
ALL	18	78	166	95	75	72	26	42	0	0	0	0	0	7	0
PART D															
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	50	56	202	0	0	0	0	0	0	0	0	0	0	0	0
7a	35	0	0	0	0	370	0	0	0	0	0	0	0	0	0
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ALL	39	15	55	0	0	267	0	0	0	0	0	0	0	0	0

LANCHESTER - FREQUENCY DISTRIBUTION (HOURS/ANNUM) OF STUDENTS' GROUP SIZES BY DISCIPLINE 1973/74

DISCIPLINE	1	2	3	4	5	6	7	8	9	10	11	12
PART A												
3	7	30	165	184	51	107	57	159	0	0	0	0
5	8	16	75	101	101	249	67	47	108	30	0	0
6	10	0	70	133	0	21	0	111	5	50	73	0
7a	10	0	0	0	500	0	0	0	0	0	0	0
8	10	0	0	30	0	0	0	549	0	0	0	0
ALL	8	13	96	134	46	95	32	136	24	26	29	0
PART B												
3	10	75	239	218	62	238	0	0	0	0	0	0
5	10	112	409	152	139	22	104	23	0	0	0	0
6	11	13	107	41	75	14	27	127	37	0	0	0
7a	10	0	0	0	490	0	0	0	0	0	0	0
8	10	0	0	0	60	555	0	0	0	0	0	0
ALL	10	51	201	115	96	104	32	58	16	0	0	0
PART C												
3	26	168	250	155	93	0	0	0	0	0	0	0
5	24	126	288	244	0	37	0	21	0	0	0	0
6	10	11	42	82	8	102	89	62	0	0	0	0
7a	8	0	0	0	243	190	0	0	0	0	0	0
8	10	0	0	0	0	60	450	0	0	0	0	0
ALL	17	81	152	131	39	59	59	29	0	0	0	0
PART D												
3	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-
6	10	123	177	0	0	0	0	0	0	0	0	0
7a	10	0	0	0	370	0	0	0	0	0	0	0
8	-	-	-	-	-	-	-	-	-	-	-	-
ALL	10	53	77	0	205	0	0	0	0	0	0	0

CORRELATION MEAN ONC/OND SCORES WITH YEARS 1972/73 BY DISCIPLINE

DISCIPLINE	1		2		3	
	N	r	N	r	N	r
LANCHESTER						
3	52	+.25	54	+.23	32	+.06
5	8	+.76	11	+.02	8	-.05
6	9	+.43	10	+.43	9	+.75
7a	-	-	-	-	-	-
8	-	-	-	-	1	-
TOTAL	69	+.40	75	+.29	50	+.31
LOUGHBOROUGH						
1	1	-	1	-	1	-
3	87	+.44	58	+.35	57	+.15
5	3	+.96	2	+1.00	6	+.73
6	2	+1.00	5	+.74	1	-
7b	-	-	-	-	-	-
8	-	-	-	-	-	-
TOTAL	93	+.44	66	+.37	65	+.25

CORRELATION MEAN ONC/OND SCORES WITH YEARS 1973/74 BY DISCIPLINE

DISCIPLINE	1		2		3	
	N	r	N	r	N	r
LANCHESTER						
3	54	+.36	39	+.29	49	-.09
5	7	+.62	7	-.43	9	+.37
6	14	+.54	10	+.29	9	-.18
7a	0	-	0	-	0	-
8	0	-	0	-	0	-
TOTAL	75	+.33	56	+.33	67	+.17
LOUGHBOROUGH						
1	2	-1.00	0	-	0	-
3	84	+.44	60	+.18	59	-.02
5	7	+.72	4	-.72	4	+.52
6	2	+1.00	4	-.45	7	+.12
7b	0	-	0	-	0	-
8	0	-	0	-	0	-
TOTAL	95	+.38	68	+.10	71	+.05

CORRELATION PART WITH PRECEEDING YEAR RESULTS UNDERGRADUATE 1972/73

DISCIPLINE	2 v 1		3 v 2		4 v 3	
LANCHESTER	N	r	N	r	N	r
3	198	+.48	211	+.62	-	-
5	152	+.39	156	+.68	-	-
6	273	+.39	252	+.59	8	+.88
7a	23	+.40	18	+.73	18	+.30
8	30	+.72	30	+.71	-	-
TOTAL	676	+.46	667	+.68	26	+.53
LOUGHBOROUGH						
1	6	+.72	2	-1.00	-	-
3	400	+.67	343	+.70	-	-
5	182	+.62	156	+.77	-	-
6	76	+.27	62	+.50	-	-
7b	18	+.75	15	+.75	-	-
8	19	+.70	27	+.74	-	-
TOTAL	701	+.63	605	+.71	-	-

CORRELATION PART WITH PRECCEDING YEAR RESULTS UNDERGRADUATE 1973/74

DISCIPLINE	2 v 1		3 v 2		4 v 3	
LANCHESTER	N	r	N	r	N	r
3	180	+.65	187	+.62	-	-
5	128	+.32	132	+.60	-	-
6	251	+.46	262	+.53	13	+.85
7a	18	+.09	22	+.54	16	+.19
8	21	+.46	31	+.56	-	-
TOTAL	598	+.54	634	+.61	29	+.43
LOUGHBOROUGH						
1	17	+.48	2	+1.00	-	-
3	431	+.63	314	+.64	-	-
5	171	+.57	161	+.61	-	-
6	148	+.73	70	+.82	-	-
7b	26	+.72	19	+.76	-	-
8	32	+.65	17	+.73	-	-
TOTAL	825	+.62	583	+.65	-	-

MEAN A-LEVEL SCORES FOR UNDERGRADUATES ENROLLED 1972/73 BY DISCIPLINE

DISCIPLINE	YEAR 1			YEAR 2			YEAR 3			YEAR 4		
LANCHESTER	N	M	SD	N	M	SD	N	M	SD	N	M	SD
3	178	1.95	0.84	100	1.91	0.85	85	2.01	0.79	-	-	-
5	194	1.80	0.72	124	1.80	0.70	112	1.83	0.89	-	-	-
6	295	2.34	0.77	242	2.42	0.73	224	2.44	0.67	6	2.73	0.40
7a	24	2.84	0.73	19	2.59	0.91	19	2.95	0.68	16	2.87	0.68
8	34	2.54	0.78	31	3.02	0.75	29	2.57	0.63	-	-	-
TOTAL	725	2.13	0.82	516	2.21	0.83	469	2.24	0.81	22	2.83	0.62
LOUGHBOROUGH												
1	21	2.55	0.73	5	3.14	0.47	1	1.70	0.00	-	-	-
3	545	2.96	0.81	329	3.00	0.82	259	2.98	0.77	-	-	-
5	205	2.79	0.80	185	2.86	0.82	150	3.07	0.81	-	-	-
6	166	2.77	0.69	65	2.66	0.70	54	2.68	0.96	-	-	-
7b	29	2.98	0.76	21	2.90	0.75	15	2.83	0.85	-	-	-
8	39	3.45	0.59	19	3.36	0.89	27	3.34	0.72	-	-	-
TOTAL	1005	2.90	0.79	624	2.93	0.82	516	2.99	0.82	-	-	-

MEAN A-LEVEL SCORES FOR UNDERGRADUATES ENROLLED 1973/74 BY DISCIPLINE

DISCIPLINE	YEAR 1			YEAR 2			YEAR 3			YEAR 4		
LANCHESTER	N	M	SD	N	M	SD	N	M	SD	N	M	SD
3	208	2.01	.85	122	1.82	.68	78	1.98	.75	-	-	-
5	156	1.80	.65	118	1.73	.64	97	1.86	.77	-	-	-
6	337	2.28	.79	244	2.37	.74	234	2.41	.72	11	2.52	.51
7a	16	2.64	.90	20	2.79	.64	19	2.59	.91	16	2.82	.98
8	51	2.52	1.03	21	2.69	.80	31	2.56	.77	-	-	-
TOTAL	768	2.13	.83	525	2.13	.78	459	2.24	.79	27	2.70	.83
LOUGHBOROUGH												
1	21	2.70	.93	18	2.61	.76	3	2.67	.70	-	-	-
3	521	2.98	.88	364	3.02	.78	253	2.97	.81	-	-	-
5	161	2.71	.89	179	2.82	.82	160	2.86	.78	-	-	-
6	138	2.74	.85	148	2.78	.70	58	2.63	.72	-	-	-
7b	51	3.29	.78	28	2.96	.77	19	2.72	.50	-	-	-
8	21	3.29	.62	32	3.49	.55	17	3.49	.89	-	-	-
TOTAL	913	2.92	.88	769	2.93	.78	510	2.90	.80	-	-	-

CORRELATION: MEAN A-LEVEL SCORES WITH YEARS UNDERGRADUATES 1972/73

DISCIPLINE	1		2		3		4	
LANCHESTER	N	r	N	r	N	r	N	r
3	158	+.22	100	+.10	85	+.19	-	-
5	182	+.00	121	-.01	111	+.38	-	-
6	281	+.20	239	+.18	221	+.12	6	+.42
7a	23	+.12	19	-.30	18	+.36	15	-.40
8	30	+.31	28	+.43	29	+.44	-	-
TOTAL	674	+.15	507	+.05	464	+.14	21	-.24
LOUGHBOROUGH								
1	21	+.38	5	-.68	1	-	-	-
3	518	+.31	320	+.31	264	+.10	-	-
5	188	+.33	176	+.28	147	+.26	-	-
6	155	+.22	61	-.07	53	-.10	-	-
7b	29	+.00	19	+.36	15	+.47	-	-
8	38	+.45	19	+.64	27	+.31	-	-
TOTAL	949	+.29	600	+.27	507	+.15	-	-

CORRELATION: MEAN A-LEVEL SCORES WITH YEARS UNDERGRADUATES 1973/74

DISCIPLINE	1		2		3		4	
LANCHESTER	N	r	N	r	N	r	N	r
3	175	+.19	120	+.05	78	+.10	-	-
5	147	+.20	111	+.11	95	+.20	-	-
6	319	+.26	231	+.13	233	+.18	11	+.44
7a	16	+.39	18	+.12	18	+.09	16	-.11
8	47	+.54	20	+.36	31	+.01	-	-
TOTAL	704	+.20	500	+.05	455	+.07	27	-.07
LOUGHBOROUGH								
1	20	+.28	17	+.36	1	-	-	-
3	481	+.40	352	+.27	246	+.14	-	-
5	154	+.21	167	+.29	158	+.14	-	-
6	122	+.44	141	+.13	56	+.11	-	-
7b	48	+.17	26	+.05	19	+.19	-	-
8	18	+.37	31	+.19	17	+.69	-	-
TOTAL	843	+.35	734	+.25	497	+.14	-	-

APPENDIX B

Statement of Author's Contribution to the Following Sample of Published Papers

In accordance with Section 3.3 of the Regulations for Higher Degrees by Research of the University of Technology, Loughborough, the following papers are submitted in support of the Thesis set out in Volume I:

All the papers have been written wholly or substantially by D W Birch. However, in the case of the discussion paper "Tracing the Efficient Frontier in British Universities" the major conceptual contribution was made by Mr J R Calvert. In every case of joint author papers the finished article has benefitted from discussions with, and comments and suggestions from, the conjoint authors.

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HIGHER EDUCATION REVIEW

The James Report: college and university attitudes
The make-believes of planning
The future for part timers
Criteria for success in FE
Notes: design for design
Books: student residence

SUMMER 1972

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Towards an objective and some criteria of success in further education

Derek W Birch and David L Parkes

The assumption which underlines much of the current search for objectives and criteria of success for the education sector and for individual educational institutions is that continued growth in educational provision cannot continually be matched by growth in the proportion of GNP devoted to it. 'More' will have to be accompanied by 'less more' resources. Hence the present attempts to bring a range of management techniques to bear on the organisation of learning.

The pressure comes from two directions: first, the application of general management principles to the processes in colleges and schools; second, the view that control techniques applied in other public sectors – like rate of return studies related to road investment schemes – should be applied to investment in the labour intensive education sector. Because of this labour intensive factor, educational planning tends to concentrate on economic or semi-economic data which relate cost of manpower to educational processes – factors like enrolments, size of classes, use of buildings, teacher hours, class hours, a longer academic year and so on.

Many observers already feel that concentration on these blurs the real planning issues which should be related to *qualitative* processes within institutions – not necessarily to rate of return on investment to the individual but to value to social welfare. This may be, but it is still necessary to sort out those areas which can be quantified, (quantification supplying a base for decision) and leaving the unquantifiable exposed for discussion by the interested parties. This paper attempts to put forward a simple model that begins to enable a distinction to be made.

A control framework

Management control is the process whereby managers ensure that resources are obtained and used efficiently in the accomplishment of organisational objectives. In most control procedures the following aspects are identifiable: objectives are agreed; the programmes and resources to achieve these aims are determined and allocated and standards of performance set; actual performance is monitored and compared with the standard, and adverse deviations are examined, analysed and, where possible, explained and remedied. The 'keys' to

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this process are the agreement of objectives and the setting of acceptable levels of performance and it is with these topics that this short paper is concerned.

The question of objectives

What are, or should be, the objectives of further education? How are they different from other formal or informal sectors of education? Agreement among educators is confined to large generalisations which tend to establish the boundaries of social policy rather than give content to realisable goals – 'to preserve the intellectual stock,' 'to enlarge human knowledge,' 'to develop given values systems in civilisation'. Equally one may be provided with sub-objectives such as the 'provision of equal educational opportunity' or 'increased mastery by the individual of his potential in the context of his environment'. From outside the practice of teaching, the perspectives of the planner tend to be bounded by particular disciplines. For example as the present Indian summer of 'the economist' draws to a close, we are left with handy phrases like 'maximising the discounted present value of expected future earnings'.

DES Planning Paper No 1[1] suggests that the main objectives for the 16-19 age cohorts (the most relevant age range) should be:

'(1) To provide education and/or vocational training for all those between the ages of 16 and 19 who wish to receive it and could profit from it.

(2) To meet the requirements of society for people with education and training to this level, either to be employed directly or to go forward for further education or vocational training'.

Staff in educational institutions may find it hard to disagree with these as main objectives. Our difficulty boils down to establishing objectives operable in a control context.

The compromise which becomes necessary is a distinction between an objective which is simple and, if possible, measurable and those which leave room for the individual institution to search for and move towards more 'ideal' states. In many ways this is how the distinction between the broad legislative and policy layers of DES and local authorities already meet with the autonomy of most schools and colleges.

However, as a starting point we suggest a necessary but not yet sufficient formula for colleges of FE might be:

'It is the purpose of a college of further education to create an environment in which a body of knowledge or a collection of skills or certain modes of behaviour (or a permutation of these three) may be learned.'.

As it stands this objective cannot be said to over-constrain a college in the search for ultimate educational ends, but is the degree of success in pursuing it measurable?

An advantage of highlighting a further education college is that it exists for the customer as a 'choice' sector beyond compulsorily schooling to 15 or 16 which makes its position somewhat analogous to that of a retail co-operative. The Co-operative Movement exists to maximise 'member benefits' and Professor McClelland[2] has argued that we cannot measure its success in this endeavour directly but that some lead is given by the volume of business that the members freely choose to transact with their 'local society'. Hence co-operatives should seek to maximise sales subject to the proviso that these sales are not made at a loss. In a nutshell his argument is that the market provides the ultimate test of any product or service. If this is so, then the extent to which the local community is prepared to take advantage of the services provided by their college, and, having sampled its wares, continue to participate in its activities, is the best indicator of its success. Therefore, in operational terms our objective can be rewritten: 'Maximise student enrolments and attendance rates'.

If one goes further and attempts to register success in terms of successful graduates from a course then the variables of assessment are reached. How to measure students who are raised from point B to F on some scale, in contrast to those raised to F from D? Indeed the 20 point scale proposed by the Schools Council for GCE exams leaves students hovering around a 'he might or might not have passed' criterion. Already one polytechnic has proposed as its entry criterion 'the ability to profit from a course' – which would create a need for individual measurement of success outside any normal scheme for percentage distribution in a group, local or national. The extent, therefore, of improvement in quality attributable to an educational process remains a matter of opinion – usually localised opinion.

Our objective runs the risk of being labelled both simplistic and philistine. For that matter the validity of profit maximisation in the private sector is equally simplistic. Do firms maximise profits, sales revenue or market share; or minimise the dangers of a takeover or merely satisfy some function which is never exactly specified but which takes into account the needs and aspirations of employers, managers and the wider society as well as the ordinary shareholders? The maximisation of profits is clearly not the whole truth, but it is a starting point. If a company continuously fails to make a profit the chances are it will go out of business. Similarly in time we may be able to set down a more sophisticated objective function for a college. Meanwhile most people would accept that a college which is empty of students is *not* a success. So we are attempting to start simply with a simple concept.

The search for a standard for comparison

Implicit in any system of control is comparison – comparison of actual performance against a measure. For the individual college this comparison could be made either internally with its performance in previous time periods, externally with the performance of other colleges over the same time-scale – or both. In educational cost control it has been suggested that the external comparison should be with a national 'norm' arrived at by an averaging process. Such a norm would reflect past and current practice rather than an 'ideal' state. Moreover, by definition a college would be as likely to perform better as worse than the norm. On the face of it, therefore, internal comparison over time seems more meaningful. However, an improvement in this year's achievement over last years is not itself a cause for self-congratulation if over the same time scale improvements in the same area of work in other colleges have been even more spectacular. Probably both internal time series and external cross section comparisons should be made. Further, the external comparison is likely to be more useful if it is made against data from individual colleges rather than a national norm.

In other words we need something similar to the Centre for Interfirm Comparisons,[3] which publishes information for each of the member firms in a sector, rather than a 'norm' for the whole industry. For a college the comparisons might be most usefully made within its own LEA or RAC;

The work in further education is complex in so far as it can be classified in at least three dimensions: by course or broad discipline area; by level – 'university' (A1 and A2), 'intermediate' (B), and 'school' (C);[4] and by the pattern of student attendance – full-time, sandwich, part-time and evening only. As far as is possible the targets set, the statistics collected and the comparisons made should recognise and provide for this heterogeneity. The monitoring and matching of actual against some standard internal or external to the college is only significant if it is a process which compares like with like.

Most colleges run a large number of courses which would need to be classified under broad discipline areas. The recent DES Pooling Committee enquiry into the establishment of cost 'norms' in advanced FE collected its student statistics in the following groups:

education;
health;
technology and engineering;
agriculture;
science and applied science;
social (administrative and business) studies;
vocational – architecture and town and country planning;
vocational – other including catering, home economics, librarianship;
nautical studies and transport;
languages (literature and area studies);
arts (other than languages); and
art and design including drama and music.

Apart from difficulties at the margins there seems no reason why this practice should not be followed for all of further education.

For some purposes (the assessment of overall college performance for example) it will be convenient to convert the various attendance patterns into full time equivalents (FTEs). How this should be done has been the subject of much debate which has resulted in a diversity of practice. The problems involved in arriving at appropriate 'multipliers' led the Capps Report[5] to eschew FTEs in favour of student hours. The apparently straightforward solution is to divide total student course hours by the average hours of attendance of a full time student over the same time period. However, in the matter of the allocation of resources, particularly, administrative 'back-up' the question remains: should a part time students' hour be counted equal to or greater than a full time students' hour, and if greater by how much? In the context of resource allocation arguments in favour of some weighting of part timers are strong. But for our purposes – college objective setting and control – it matters little how one obtains the conversion to FTEs so long as the practice is consistent between colleges and within a college over time. Nevertheless as far as inter-college comparisons are concerned there is scope for rationalisation and for DES guidelines with regard to lengths of terms and college day.

The critical ratios

We have argued above that a college should set out to maximise local involvement in its course mix. At this stage we cannot specify an optimising model, but we can obtain some information on the college's search for this target by comparing actual student hours in one period with actual student hours in a previous period. Insofar as actual student hours are dependent upon enrolments and subsequent attendance rates we can establish a pyramid of ratios thus:

$$\frac{\text{Actual student hours in period t}}{\text{Actual student hours in period t-1}}$$

$$=$$

$$\frac{\text{Enrolments in period t}}{\text{Enrolments in period t-1}} \times \frac{\text{Attendance rates in period t}}{\text{Attendance rates in period t-1}}$$

$$\text{where Attendance rate} = \frac{\text{Actual student hours}}{\text{Potential student hours}}$$

and Potential hours = Enrolments times the length of the course in hours.

The data required to construct these ratios – enrolments, actual and potential student hours – are readily available. An example of the calculation of these ratios follows in Table 1.

It would be possible and probably more useful to analyse the enrolments and attendance rates further on the basis of either departments or, for inter-college comparisons, agreed discipline areas and the levels of work A1, A2, B and C. A ratio greater than unity represents an improvement in performance. How much of an improve-

TABLE 1
(Performance ratios : An example)

At t

	Enrolments	Potential hours	Actual hours
full time	1,000	1,000,000	900,000
part time day	3,000	600,000	480,000
evening only	2,000	200,000	120,000
	6,000	1,800,000	1,500,000

At t-1

	Enrolments	Potential hours	Actual hours
full time	800	800,000	650,000
part time day	2,500	500,000	400,000
evening only	2,000	200,000	150,000
	5,300	1,500,000	1,200,000

Performance ratios:

Overall
$$\frac{1,500,000}{1,200,000} = 1.25$$

$$\frac{1,800,000/1,000}{1,500,000/1,000} = 1.20 \qquad \frac{1,500,000/1,800,000}{1,200,000/1,500,000} = 1.04$$

Full time
$$\frac{900,000}{650,000} = 1.38$$

$$\frac{1,000,000/1,000}{800,000/1,000} = 1.25 \qquad \frac{900,000/1,000,000}{650,000/800,000} = 1.11$$

Part time day
$$\frac{480,000}{400,000} = 1.20$$

$$\frac{600,000/1,000}{500,000/1,000} = 1.20 \qquad \frac{480,000/600,000}{400,000/500,000} = 1.00$$

Evening only
$$\frac{120,000}{150,000} = 0.80$$

$$\frac{200,000/1,000}{200,000/1,000} = 1.00 \qquad \frac{120,000/200,000}{150,000/200,000} = 0.80$$

Notes

Enrolments = $\frac{\text{Total potential hours}}{\text{Average hours a year of a full time student}}$ = FTE s

The calculations assume that the average course hours of a full time student = 1,000 a year.

ment would depend upon the performance of other colleges over the same time scale; a cross-section comparison would be necessary before coming to any firm conclusions.

Enrolments are a function of the college's past reputation, the effectiveness of its marketing and the relevance of its course mix to local needs. The enrolment ratio is also influenced by factors outside the college like population shifts and population growth. The attendance rate, on the other hand, is affected by variables which are largely internal to the college and, hence, more controllable. It reflects the efficiency of the learning environment: the adequacy or otherwise of the selection procedures, the teaching method, the deployment of educational technology, allied with adequate guidance and counselling – matters which are all very much within the province of the academic staff. Consequently attendance ratios of much less than unity would require careful investigation.

The constraints

An objective of the maximisation of student hours will be pursued by a college against a backcloth of constraints – the inflexibility of its buildings, the strategy of its local authority, the policy of the DES and so on. Arguably one of the most important of these constraints will be the cost per student. Information on the precise cost structures of colleges is hard to come by and even if it were available unit cost comparisons over time would be bugged by the problem of inflation. What is certain is that teachers' salaries account for between 50 and 60 per cent of the annual expenditure of a college. We concentrate on this particular expense and examine some of the factors which determine its level.

Delany[6] has argued that the level of staff requirement is given by the formula:

$$N = \frac{\text{FTEs.}}{\text{ACS}} \cdot \frac{a}{b} \qquad \ldots\ldots 1$$

where FTEs = $\dfrac{\text{total potential student course hours a year}}{\text{course hours of a full time student a year}}$

ACS = average class size

a = that proportion of the working week (or year) that the average class is supervised by a teacher, or the class's 'teacher contact' time : the "curriculum volume factor".

b = that proportion of the working week (or year) that the average teacher spends supervising a class, or his 'class-contact' time : the "staff deployment factor".

N = staff requirement of full time equivalent teachers.

Thus the staff/student ratio is

$$\frac{N}{FTEs} = \frac{a}{ACS \cdot b} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

From equation I it can be seen that if ACS, a and b remain constant then N will increase in direct proportion to the increase in FTEs, and a condition of constant average staff costs will have been attained. However, if either ACS or b increase or a decreases then an increase in FTEs will imply a less than proportionate increase in N, and average academic staff costs per student will have been lowered. From a cost viewpoint constant average costs are a minimum standard to be aimed at and a situation of decreasing average costs is preferable. Consequently to our objective of the maximisation of the student hours, enrolment and attendance ratios we can now add the proviso that the staff student ratio is maintained at least constant, or, more generally:

That $\dfrac{a}{ACS \cdot b}$ at t $\leqslant \dfrac{a}{ACS \cdot b}$ at t-1

The advantage of defining the staff student ratio as in equation 2 above is that it highlights the important variables: average class size, curriculum volume factor and staff deployment factor. Faced with the problem of meeting a specific staff/student ratio the principal or head of department may choose to operate on ACS or a or b or any combination of these. In the event Burnham 'recommendations' and ATTI 'understandings' with the local authorities are likely to restrict the room for manoeuvre on the staff deployment factor. Average class size and, particularly, curriculum volume factor remain real options; though fully to exploit their possibilities would probably involve an increase in the investment in educational technology.

We have not attempted to go beyond our initial hesitant claims to begin to expose a simple model where measurement is possible. Beyond this model lie the complex arguments between national and local measurements on the one hand and on the other the internal processes of a college where the participative mode of a collegial form of government allow key qualitative decisions to be made collectively. Other non-legislative pressures like externally organised educational research have a function here, too, but to take account of them we should have to begin to examine the process of education as it exists outside institutions in an information rich society, when the fundamental concepts of institution-based learning would come under challenge and measurement criteria be made more complex still.

References and Notes

[1] Education Planning Paper No 1 *Output Budgeting for the DES* HMSO 1970.
[2] W G McClelland *Costs and Competition in Retailing* Macmillan 1967, p 146.
[3] The Centre for Interfirm Comparison Ltd., London, is an organisation set up in 1959 by The British Institute of Management in association with the British Productivity Council to meet the demand of industry and trade for an expert body to conduct interfirm comparisons on a confidential basis.
[4] See Burnham Report: *Scales of Salaries for Teachers in Establishments for Further Education* 1965 HMSO Appendix VI para 3 for precise definition.
[5] *A Report on the Use of Costing and other Financial Techniques in Technical Colleges* by the Committee on the More Effective Use of Technical College Resources (Pilkington) HMSO 1969.
[6] V J Delany *Cost Efficiency Indicators in Further Education* The Association of Colleges of Further and Higher Education, February, 1971.

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HIGHER EDUCATION REVIEW

From class to mass in higher education
Student preference and university planning
How profitable is teaching?
The academic as administrator
and policy maker
Notes: overweening ambition
Books: teacher supply

AUTUMN 1973

+1

How profitable is teaching?

D W Birch and J R Calvert

What are the economic benefits derived from the decision to invest in a teacher's certificate, or to obtain a degree, a postgraduate teaching certificate and then follow a teaching career? Are these benefits greater than the costs involved in becoming a qualified teacher?[1] These are the questions we attempt to answer in the first part of this paper. We do so from the point of view of the individual taking the decision to become or not to become a teacher rather than from the nation's standpoint. It may be as well to preface our analysis by emphasising the point that we are concerned solely with an economic evaluation. Plainly there are educational, cultural and social ramifications to the investment but a calculus for assessing these objectively has yet to be developed. It seems reasonable to assume, however, that these other aspects would add to rather than subtract from the economic return.

Economic evaluation of an investment opportunity:

The theoretical framework of the economic evaluation of an investment in education is well settled and is not different from the economic appraisal of the opportunity to invest in an item of capital equipment.[2] We may define an investment in this context as an outlay of cash or resources now or in the near future to acquire an asset in the expectation of receiving in the longer run a larger stream of cash or other economic benefits as a result of holding the asset: the extent of the investment horizon is the expected lifetime of the asset. To evaluate an investment, therefore, we have to measure and compare outflows (costs) and inflows (benefits) which arise at different points in time. This is accomplished by discounting the costs and benefits by an appropriate rate of interest to achieve a comparison at present values. Formally the net (benefits less costs) present value of an investment is given by

$$\sum_{t=0}^{t=n} = (B_t - C_t)\ (1 + r)^{-t} \qquad (1)$$

where

$\sum_{t=0}^{t=n}$ = the sum of from t=0 to t=n;

(eg if we were assessing the decision at the age of 15 to aim for a teachers certificate and then follow a teaching career t=0 would correspond to age 15 and t=n to retirement at age 65.)

H2

B_t and C_t = respectively the benefits and costs which are assumed to arise at the end of year t; and

r = the discount factor.

What r should be in investment appraisal in the public sector is a matter of some controversy. Therefore, it is usual to employ an alternative investment appraisal formula - the 'internal rate of return'. The internal rate of return is that rate i which solves the following equation

$$\sum_{t=0}^{t=n} (B_t - C_t)(1+i)^{-t} = 0 \qquad (2)$$

The rates of return we derive below are for the most part the result of following a slight variation on (2). Specifically they are those rates i which equate the present value of the lifetime benefits stream of the total population with the lifetime benefits stream of teachers: ie

$$\sum_{t=0}^{t=n} (F_{xt} - F_{yt})(1+i)^{-t} = 0 \qquad (3)$$

where

F_{xt} = the expected cash flows of the total population in year t; and
F_{yt} = the expected cash flows of teachers in year t.

The relevant benefits and costs

The identification and estimation of the benefits and costs is a hazardous business in any investment appraisal exercise. This is particularly so in education investment appraisal where the investment is in human beings. The discounting models discussed above appear to be exact but the precision of the calculations depends upon the accuracy of the benefits and costs estimates and in the appraisal of an education investment opportunity we are relying on proxy measures at various points. If we are examining an education investment opportunity from the point of view of an individual the relevant benefits are the extra earnings he might expect to receive during his working lifetime as a result of undergoing the educational process; the relevant costs are largely his loss of earnings less any grant received during his study period. Strictly speaking the benefits should be calculated net of personal tax. The tax rates, of course, will depend upon domestic circumstances and will vary from individual to individual. It is usual to assume some representative personal tax situation and that this will remain stable over time. In fact unless one assumes that the tax situation for teachers in terms of fixed allowances and tax rate is different from that for the total population the rates of return will be only slightly affected by tax adjustments. On the grounds that the necessary tax assumptions compound the articificiality of the investment appraisal exercise, and in the belief that individuals assess career opportunities on the basis of gross rather than net salaries, we have ignored the tax adjustments.

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The most meaningful view of the rate of return on an investment in a given educational qualification is to compare its net benefits (ie expected lifetime earnings net of costs) with those of the next lower level of education. However, we are concerned with the economic implications of the individual's decision at the age of 15 to opt for a teaching career as against all other career possibilities. Consequently, the type of comparison we have used is of the lifetime earnings of teachers, taking into account their students grants and vacation earnings, with the lifetime earnings of the total population. The age earnings profiles of the total population might also be taken as a proxy for the unqualified.[3]

The data base

Consider a group of people aged 15: what are their expected lifetime earnings? An estimate of the expected cash flows at a particular age is given by

$$(A)(B)(C) \tag{4}$$

where

- A = Proportion of the group that would be alive;
- B = Proportion of the group that, if alive, would be economically active/employed;
- C = The median salary at a particular age of the economically active/employed members of the group.

Each of these values requires a longitudinal study but, as is normal in educational rate of return studies, we have used cross sectional data. The age-earnings profiles were derived from DES Statistics of Education 1970 and the New Earnings Survey 1970; information on the proportions economically active and the proportions employed was obtained from the 1966 Sample Census; and the survival rates were derived from data in the Registrar Generals' Decennial Supplement 1961 and Report 1968. The data were divided by sex and also, for teachers, by graduates/non graduates and primary/secondary. The nature of our data base and our analysis of and adjustments to it are summarised in the appendix.

These calculations gave us the annual expected earnings from the age of 15 to 65 after adjusting for the probability of survival and the probability of being economically active. An adjustment substituted for the latter the probability of being employed. As the survival rates are high except in the later years which are heavily affected by the discounting process the survival correction has little influence on the final present value calculations. The overall effect of the economic activity/employment adjustments is to reduce the expected benefits particularly for females. However, women teachers have a higher activity/employment rate than women generally and this is reflected in the final rates of return.

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The rates of return

The benefit streams thus derived were discounted by various rates of interest from 0 to 40 percent to obtain the present values. A search was then made to identify that rate of interest which equated the present values of the expected benefit streams of the total population with those of teachers (ie the rates of interest which satisfy equation (3) above). These rates of return are shown below in Table 1.

TABLE 1

Alternative estimates of private rates of return on the investment in a teaching career from age 15 (1970)

		Percentages economically active	Percentages in employment
Males	All graduates	11.7	11.9
	graduates : secondary	11.9	12.1
	graduates : primary	8.7	8.9
	All non graduates	6.9	7.0
	non graduates : secondary	6.9	7.0
	non graduates : primary	6.8	6.9
Females	All graduates	27.5	29.0
	graduates : secondary	28.1	29.8
	graduates : primary	26.5	28.3
	All non graduates	26.8	28.5
	non graduates : secondary	27.5	29.5
	non graduates : primary	26.5	28.3

In 1970 it was possible to leave school at 15 to obtain full-time employment: today the school leaving age is 16. The rates of return in Table 1 are based on lifetime earnings expectations at the age of 15; if these are corrected to expectations at age 16 the effects are to raise the rates for men by about ½ percent and for women by about 3½ percent. It is popularly claimed that one of the 'perks' of teachers is their longer than average holidays. Plainly some of this extra holiday expectation is taken up with further study, class preparation and so on but some of it might be used to earn extra money or to pursue activities of equal value to the teacher. Therefore, to take some account of this 'perk' all the benefit streams for teachers, from age 21 for non graduates and age 22 for graduates, were adjusted upwards by 1/12 (ie one extra month's salary). The results in terms of the new rates of return are given in Table 2. The effects of the holiday adjustment are to narrow slightly the differences between the returns to graduates and non graduates and to increase the returns to men overall from 2½ percent to 3 percent and the returns to women overall from 1½ percent to 2½ percent.

Conclusions so far

In all cases the rates of return are positive and therefore we may conclude that under the present free tuition and maintenance grant

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TABLE 2

Alternative estimates of private rates of return on the investment in a teaching career from age 15 adjusted for holiday 'perks' (1970)

		Percentages economically active	Percentages in employment
Males	All graduates	14.1	14.4
	graduates : secondary	14.3	14.6
	graduates : primary	11.2	11.4
	All non graduates	9.6	9.8
	non graduates : secondary	9.7	9.9
	non graduates : primary	9.4	9.6
Females	All graduates	29.3	31.0
	graduates : secondary	29.8	31.5
	graduates : primary	28.3	29.9
	All non graduates	29.0	31.0
	non graduates : secondary	29.8	31.5
	non graduates : primary	28.8	30.5

provisions the decision to invest in a teaching career is economically a worthwhile one. The decision to teach is much more profitable for women than for men. However the high rates of return enjoyed by women teachers are more a commentary on the poor state of the female labour market than they are evidence of high salaries for women teachers. They are the result firstly, of equal pay and secondly, of female teachers' high economic activity as compared with women generally. For the present, teaching fits in better with a woman's child-bearing and subsequent domestic responsibilities than most other careers. In the longer run future equal pay legislation and the changing social climate on women at work are likely to erode the substantial economic advantages currently enjoyed by female teachers. Apparently the important decision for women is the one to become a teacher; thereafter the choices between graduate and non graduate status and between a career in secondary rather than primary education have little effect on the economic rate of return. However, for men graduate status clearly enhances economic rate of return expectations although this advantage is reduced somewhat if the male teacher opts for a career in primary rather than secondary education.

A recent paper by Adrian Ziderman[4] offers us the opportunity of a limited comparison of teachers' rates of return with other 'qualified' career opportunities. He uses the age earnings profiles of the total population as a proxy for the 'unqualified' and compares this with data on earnings for graduates and holders of GCE A level. His adjustments for life expectancy, economic activity and employment appear to be similar to our own. However, he uses mean rather than median (the more usual measures in education rate of return studies) salaries and he corrects for personal taxation. He also adds on 2 percent to the rates of return as a 'conservative' estimate of the expected increase in real earnings over a lifetime. This adjustment is reasonable if we assume that the supply and demand for each type of educated manpower moves in line so preserving current relative income differentials. His findings after these adjustments are as follows.

TABLE 3

Private rates of return on education from age 15 (1966-67)

	Percentages	
	Males	Females
First degree	15.0	20.5
GCE A level	10.0	–

Note: There were insufficient data to calculate the rate of return for female holders of GCE A Level.

It might be argued that so far as teachers are concerned past experience has been to narrow rather than widen their absolute income differentials over the rest of the community. Therefore, the addition of 2 percent to take some account of future expected increases in real earnings is unjustified. Nonetheless if we add 2 percent to the rates identified in Tables 1 and 2 a more direct comparison with the results of Table 3 is possible. However it should be noted that Tables 1 and 2 are based on earnings data for 1970 whilst Table 3 is based on the pattern of earnings in 1966-67. The rate of return for female graduate teachers is from 9 percent to 11 percent higher than that identified by Ziderman for all female graduates. This confirms our view that teaching is, at this moment, a very profitable career for a woman. As might have been expected the rates of return for male graduate teachers are less than for male graduates generally. However, the economic return for male graduates teaching in secondary education is only slightly lower – 14 percent as compared with 15 percent – and much closer to the rate of return for all male graduates than we had expected. If account is taken of teachers' longer than average holidays the rates of return for male graduate teachers compare favourably with male graduates following other careers.

So much for the good news, the bad news so far as teachers are concerned is the rather indifferent rate of return for male non graduates, 9 percent as compared with 10 percent for GCE A level holders. However, since age specific earnings data relating to GCE A level holders was not obtainable from the earnings sub-sample follow up to the 1966 sample census, Ziderman was forced to use a less than satisfactory alternative estimate: ie the salary scales of the executive class of the Civil Service (for which A level is the normal entry requirement) and assuming representative promotional patterns within the class. Given the high level of Civil Service salaries Ziderman concedes that this could have resulted in an over estimate of the rate of return. Hence it might be safer to suggest that for male non graduates a career in the executive class of the Civil Service appears on average to be slightly more profitable than a teaching career.

The non graduate teacher and the Open University

Thus far we have examined the economic returns to the decision at age 15 to invest in a teaching career as compared with all other career opportunities. We now turn to briefly consider the investment opportunity offered by the Open University to the non graduate teacher at various points in his teaching career.[5] A degree at the Open University is granted after a student has successfully completed two foundation courses plus four other 'credits' for a pass degree and six for an honours degree. A teacher who has attended a three year full time course at a college of education may claim three 'credit' exemptions if he opts to follow further studies in education at the Open University. We shall assume that teachers take advantage of this possibility. We have made a number of other assumptions which are detailed below:

That the teacher follows an honours course spread over four years thus:
Year one : two credits
Year two : one credit
Year three : one credit
Year four : one credit;
That the teacher pays his own tuition fees (£10 initial registration fee plus £25 per credit) and spends £25 on books for each 'credit';
That the teacher receives a grant from his LEA to cover the cost of any 'summer schools'; and
That each 'credit' involves the teacher in 400 hours' study. (We cannot put a precise value on this foregone leisure but bearing in mind the importance of opportunity cost we have assumed three different values of 0 new pence, 50 new pence and 100 new pence per hour.)

Table 4 sets out the pattern of monetary and opportunity costs resulting from the above assumptions.

TABLE 4

Annual monetary and opportunity costs of a degree course at the Open University

Year course:	Value per hour of foregone leisure: 0p	50p	100p
1	110	510	910
2	50	250	450
3	50	250	450
4	50	250	450

The matrices of private rates of return based on six ages of entry to the Open University and three alternative valuations of foregone leisure time; and assuming that the teacher will immediately move from the non graduate to the graduate age earnings profiles are presented in Tables 5 and 6.

TABLE 5

Private rates of return to MALE non graduate teachers investing in a degree course at the Open University:-

Age of Entry	All			Primary			Secondary		
	0p	50p	100p	0p	50p	100p	0p	50p	100p
25	50.0	18.0	11.5	29.0	8.0	4.0	51.0	19.0	12.5
30	53.0	19.0	12.0	26.0	7.0	3.5	54.0	20.5	13.0
35	53.0	19.0	12.0	25.0	7.0	3.0	57.0	21.5	13.5
40	54.0	20.0	11.5	27.5	7.0	2.5	59.0	22.0	14.0
45	55.5	19.5	10.5	31.0	7.0	1.0	61.0	22.5	13.0
50	55.0	17.0	7.5	33.0	4.5	<0	62.0	21.0	10.5

TABLE 6

Private rates of return to FEMALE non graduate teachers investing in a degree course at the Open University

Age of Entry	All			Primary			Secondary		
	0p	50p	100p	0p	50p	100p	0p	50p	100p
25	38.0	14.0	9.0	27.0	8.0	4.0	35.0	13.0	8.5
30	45.0	16.5	10.0	28.0	8.5	4.0	41.0	15.0	9.5
35	50.0	18.0	11.0	31.0	9.0	4.0	47.0	17.0	10.5
40	54.0	19.0	10.5	34.0	9.0	3.0	52.5	18.0	10.5
45	54.0	17.5	8.5	35.0	7.0	0.5	54.0	18.0	8.5
50	50.0	12.5	2.5	33.0	2.5	<0	51.0	13.0	3.0

If the teacher places no value on his lost leisure time, the rates of return on the investment in an Open University degree are formidable (from 27.0 to 62.0 per cent) for all ages of entry for both primary and secondary, male and female teachers. However, this assumption of nil opportunity cost is probably unrealistic in the majority of cases. When each leisure hour lost in study is valued at 50p, the rates of return are reduced substantially but are still very worthwhile for secondary teachers varying from 13.0 to 22.5 per cent. For primary teachers at this level of opportunity cost the economic viability of the venture is more marginal (from 2.5 to 9.0 per cent for women and from 4.5 to 8.0 per cent for men). At an opportunity cost of 100p per lost leisure hour the economic case for primary teachers investing in an Open University degree is somewhat shaky. Indeed, at age 50 the returns to both male and female teachers are negative. For secondary teachers the investment remains profitable (especially for men) even at this level of opportunity cost.

A general conclusion from the preceding analysis is that the Open University will continue to receive substantial support from non graduate teachers. We would expect this support to come primarily from male secondary teachers: for them the investment opportunity is very profitable for all six ages of entry and three levels of opportunity cost examined.

Notes

1. Our attention was drawn to these questions by Colin Turner of the Further Education Staff College. However the responsibility for our answers is ours alone!
2. M Blaug 'The rate of return on investment in education in Great Britain', *Manchester School*, September 1965 pp 205-62.
3. See for example V Morris and A Ziderman 'The economic return on investment in higher education in England and Wales', *Economic Trends* No 211, May 1971.
4. A Ziderman 'Does it pay to take a degree? The profitability of private investment in university education in Britain', *Oxford Economic Papers* Vol 15 No 2, July 1973, pp 262-274.
5. This question was first considered by K Hinchliffe, 'Teachers, the Open University and the rate of return', *Higher Education Review*, Summer 1971.

APPENDIX

The data base, analysis and adjustments

A Survival rates

Teachers, male/female	Total population male/female
Registrar General's Decennial Supplement 1961	*Registrar General's Report 1968*
Proportions of 10,000 aged 0 dying in age ranges with mid points 20, 30, 40, 50, 60; Translated into proportions of 10,000 aged 15; Converted to survival proportions; These points were then plotted on a graph and the yearly values for ages 15-65 were read off the smoothed curve.	Proportions of 10,000 aged 0 surviving to reach at least 20, 25, 30, 35, 40, 45, 50, 55, 60, 65 Translated into proportions of 10,000 aged 15; These points were then plotted on a graph and the yearly values for ages 15-65 were read off the smoothed curve.

B Economically active/employed

All qualified females	Qualified in education level 'C' females	Total population females	Total Population males

1966 Sample Census

Medians for both sexes for ranges with mid points, 23, 27½, 32½, 37½, 42½, 47½, 52½, 57½, 62½, There seems no reason to suppose that qualified males are less active than unqualified males and there	Medians for each sex for each age 15-20 and for ranges with mid-points 23, 27½, 32½, 37½, 42½, 47½, 52½, 57½, 62½,.

is little room for them to be more economically active. Thus little error should result from assuming that all males, qualified and unqualified, are equally economically active. The qualified rates involve males and females and in fact mirror the two population curves. This indicates that women have a consistent pattern of economic activity, although at varying levels for qualified and unqualified. Hence, assuming all males are equally active we can deduce the qualified female rates (given the proportion of qualified males and females) with a small expectation of error;

These were then plotted on a graph and the yearly values for ages 21-65 were read off the smoothed curve.

These points were then plotted on a graph and the yearly values for ages 15-65 were read off the smoothed curve.

Since average student earnings are used elsewhere we have put the rates to 1 for ages 15-20 for all teachers.

An identical procedure to that described above for the economic activity rates was used to derive the proportions employed.

C Expected earnings:

Teachers
Male/female
Graduate/non graduate
Primary/secondary
DES *Statistics of Education* Vol IV March 1970 (Total Population of teachers)
Medians for age ranges with mid-points 23, 27½, 35, 45, 55, 62½ were calculated;
These points were plotted on a graph and the yearly values for ages 21-65 were read off the smoothed curve;
Benefit flows for ages 15, 16, 17 taken as 0 and for 18, 19, 20, for non graduate teachers, and 18, 19, 20, and 21, for graduate teachers taken as grant £360 plus Vacation Earnings £100 = £460.

Total population
Male/female
New Earnings Survey April 1970 Department of Employment (1 percent Sample)
Medians for age ranges with mid-points: 16½, 19½, 23, 27½, 35, 45, 55, 62½.
These points were plotted on a graph and the yearly values for ages 15-65 were read off the smoothed curve.
The benefit flows for ages 15 onwards were adjusted by the "student rate" to include cash flows 0, 0, 0, 460, 460, ... to incorporate student income into total population figures.

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RESOURCES PLANNING IN THE POLYTECHNICS

Proceedings of the Summer Conference in July 1973 organised by North East London Polytechnic

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ACADEMIC STAFFING FORMULAE: WITH PARTICULAR REFERENCE TO ADVANCED FURTHER EDUCATION

Derek W Birch, John L Davies and John R Calvert

The Environment

We begin by rehearsing some of the background to the Pooling Committee's recent investigations into academic staffing levels in advanced further education, culminating in the memorandum to local authorities which sets *norm* staff to student ratio bands of 7.5 to 8.5 for laboratory-based subjects and 9.2 to 10.2 for classroom-based subjects. Serious public concern to improve the management of institutions of higher education (in terms of cost per student) is a comparatively recent phenomenon. True, as far as further education is concerned, we have had the Pilkington and Hunt Committee sitting since 1964 exhorting the system to 'do better'(1) cost-wise, but in the main, until about 1967 to 68 expansion rather than cost per student was the primary interest. During the 1960s the development of criteria for planning and assessing the effectiveness of resource allocation at the macro level in education was emphasized and the so-called *manpower forecasting* and *rate of return* schools prospered. There has long been a need for diagnostic planning and control tools at the institutional level. The staffing formulae discussed below are indicative of the switch in emphasis from macro to micro analysis in the management of further and higher education.

Tables 1 and 2 examine the growth rate in full-time equivalent students and public expenditure in higher education in England and Wales from 1966-67 to 1970-71. If we allow for the *relative price effects* of labour intensive industry like education; and also in the case of advanced further education, allow for an *improvement factor* (a necessary element if the resource provision in advanced further education is to approximate to that obtaining in the universities) then expenditure has not noticeably outrun the rather crude productivity measure of full-time equivalent students. On the other hand, there is little evidence that higher education has been able to take advantage of economies of scale and the possibility of economies of scale is implicit if not explicit in much of the debate surrounding the polytechnic policy.

Table 1

Percentage growth per annum England and Wales students full-time equivalent.

	66/67	67/68	68/69	69/70	70/71	Average
Universities	9.9	8.5	5.9	3.7	3.9	6.4
Colleges of Education	16.7	18.7	8.2	2.7	1.6	9.6
Advanced Further Education full-time and sandwich	16.0	21.0	8.5	8.5	5.9	13.5
Total:	12.9	13.7	8.6	4.5	3.7	8.7

Source: DES Statistics of Education, HMSO.

Table 2

Percentage growth per annum England and Wales public expenditure

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	66/67	67/68	68/69	69/70	70/71	Average
Universities	9.6	8.3	1.7	3.4	17.4	8.1
Colleges of Education	17.6	16.1	10.3	7.3	8.6	12.0
Advanced Further Education full-time and sandwich	20.2	22.5	14.5	13.3	16.0	17.3
Total:	12.6	12.0	5.6	6.0	15.3	10.3

Source: DES Statistics of Education, HMSO.

It has been argued(2) that the methods of financing higher education have in the past precluded any economic advantage from increased size. The allocation of current expenditure in the universities and colleges has been, and is, largely based on the staff student ratio. So long as this was maintained constant the best we could hope for was a situation of constant costs. As far as advanced further education is concerned current resources have been determined by class contact hours. If Burnham(3) *understandings* are maintained this again leads, at best, to a situation of constant costs.

However, there was some basis for the belief that marginal costs in advanced further education would rise, initially at any rate, with expansion. Firstly, an increase in the proportion of advanced work leads to an upgrading of a college's academic staff establishment, and these higher post gradings in turn lead to fewer *contact hours*, (i.e. on the face of it the same staff could be paid more for teaching less). Secondly, the *pooling* procedures were suspect. *Providing* authorities submit claims on the advanced pool on the basis of the following formula:

$$\frac{\text{Volume of lecturers' salaries on advanced work}}{\text{Total lecturers' salaries}} \times \text{Net college expenditure}$$

whilst *all* authorities contribute to the pool on the basis of their population and rateable value. From the providing authorities' viewpoint, the formula argues strongly in favour of as low a staff student ratio as is possible for advanced work. The total of *poolable* expenditure is determined in arrears and until recently no generally accepted criteria for assessing the *reasonableness* of a claim existed. In theory at any rate there were opportunities for unscrupulous authorities to *milk* the pool. As far as we know there is no evidence to suggest that this was indeed happening. However, so long as the *net contributing* authorities believed that an inequitable distribution of resources between institutions was possible there was mounting pressure for a review and a reform of the pool's operations, and an end to its *open-ended* commitment.

Referring back to Table 2 we see that over the period 1966-67 to 1970-71 the average annual percentage rate of growth in public expenditure for all higher education in England and Wales was 10.3 percent.(4) Over this same period the average growth in the gross national product at factor cost was 6.0 percent. In the context of successive governments' avowed interest in curbing public expenditure this *state* was bound to attract publicity. The gross national product comparisons apart, in the rather more parochial local authority finance field the growth in absolute terms in advanced further education pooled expenditure from £44 million in 1966-67 to

£81 million in 1970-71 inevitably caused concern.

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The Development of Staffing Formulae

The largest single element in most institutions' budgets is academic staff. To be able to calculate the total requirement for academic staff and to distribute this rationally between competing departments and sections is, therefore, of critical importance. Add to this the fact that other costs tend to follow academic staff costs and it is not surprising to find a considerable research effort in this area.

The traditional academic staff resource allocation mechanism was, and is, the staff to student ratio. However, successive studies have gone behind this rather crude device to further examine the factors which determine the requirement for academic staff.

The Robbins Committee [5] identified the parameters as follows:

$T = f(s,t,h,g)$

where T = fte academic staff;

s = fte students;

t = average teaching load (formal *class-contact*) hours per week per fte academic staff member;

g = average group (class) size; and

h = average tuition load (formal *teacher-contact*) hours per week of the average group (class) g.

One simple specification of the relationship would be:

$$T = \frac{s}{g} \cdot \frac{h}{t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

and, hence, the SSR (staff to student ratio) is defined as:

$$SSR = \frac{h}{g.t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

This relationship is the one postulated by John Delany [6] and is the basis for the Pooling Committee's recommendations in the *Assessment of Curricular Activity and Utilization of Staff Resources.* [7]

There are, of course, possible improvements to Equation (1). For example the total number of teaching hours provided per week (h) might be divided into hours given in the form of lectures (k) and hours given in smaller group situations called, for the sake of a name, seminars (m). i.e. $h = k + m$

Assuming that a lecture can be delivered to an audience of 200 or more (i.e. group size is not critical for lectures although accommodation, saving the deployment of educational technology, may be) then the average group size (g) now refers to seminar group size. Again, since the parameters (k) (m) and (g) may vary by the level of students a distinction could be drawn along these lines too. Thus, with two level (say undergraduates and postgraduates) Equation (1) might be rewritten:-

$$T = \frac{k_1 + \frac{s_1}{g_1} m_1 + k_2 + \frac{s_2}{g_2} m_2}{t} \quad \ldots\ldots\ldots\ldots\ldots (3)$$

where subscripts 1 and 2 refer to first and higher degree students respectively. Equation 3 is similar to the relationship proposed by Legg [8].

Bottomley et al[9] have put forward a more generalized version similar to Equation (4) below which emphasizes the importance of the educational strategy deployed reflected in the pattern of different types of meeting:-

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$$T = \frac{\sum h_{ij} \cdot s_j/g_{ij}}{t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

where h_{ij} = average number of formal tuition hours per week received by each type of teaching meeting i in the jth year of the course;

s_j = number of students enrolled in year j of the course; and

g_{ij} = maximum size of each type of meeting; in the jth year of the course and the meeting types are analysed under the following classification:-

Lectures; Exercise Classes; Discussion Classes; Seminars or Small group discussion; Tutorials; and Practice Classes or Laboratories.

The University of Lancaster CERI-OECD research group[10] in determining their teaching load have developed a model which takes account of lecture and seminar preparation and *post-mortem* time as well as the actual formal student-teacher contact time and have derived a relationship roughly similar to Equation (5):-

$$T = \frac{k(1 + p) + \frac{s}{g}m\ (1 + \frac{q}{r}) + su}{t} \quad \ldots\ldots\ldots\ldots (5)$$

Where p = average preparation time hours per week per lecture;

q = average preparation time hours per week per seminar;

r = average number of seminar *repeats* per week per member of staff; and

u = average *post-mortem* time per student per week

However, they experienced difficulty in collecting data on *preparation* times and concede that a teacher's estimate of these might be more a measure of his experience than of his industry. Insofar as it is difficult to obtain reliable data on preparation and post-mortem times directly, it seems preferable to allow for them indirectly as a part of the reciprocal of (t) - the average formal class contact of a fte teacher.

A survey by the OECD Centre for Educational Research and Innovation of universities in member countries based on the Legg formula (approximately to Equation (3)) revealed the information tabulated in Table 3 (overleaf). An analysis of variance[11] of the data supported the contention that each subject field has its own peculiar pedagogical problems and the teaching and learning environments developed (as reflected in (h) (k) and (m) at any rate) will be much influenced by subject field.

In the Spring Term of 1970 a similar survey of all further education colleges with 50 percent or more of their work at A_1 and A_2 level was commissioned by the Pooling Committee. The data was collected under ten broad subject classifications and analysed according to the equation (1) to reveal for each institution the factors (g) (h) and (t). The response rate was high but, unfortunately, an understanding given by the Pooling Committee to the institutions and authorities providing the data has prevented the publication of the results. What is known is that there were fairly wide dispersions around the means for each of the factors; the pattern across subjects reflected the CERI study except that (h) and (t) were consistently higher and (g) was consistently lower; and the analysis apparently supported the making of a broad distinction between laboratory-based (e.g. science and technology etc.) and classroom-based (e.g. humanities and social sciences etc.) disciplines.

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The Uses and Limitations of Staffing Formulae

The first and most obvious use of academic staffing formulae such as those defined above is that they provide a basis for resource provision. However, whilst individual institutions (Loughborough University for example) may apply such formulae to assess internal allocations, at a national level the distribution of academic staff resources continues on the basis of staff to student ratios.

A second use of staffing formulae, which follows directly from the previous paragraph, is that they form a basis for data collection which can be used to support staff student ratio targets. The recently introduced targets for advanced further education were (presumably) based on the data analysis of the 1970 survey. If staff student ratio *norms* are based on historical measures of central tendency then care is needed to ensure that the data is collected in a reasonably *stable-state* situation or that it is continuously updated, or, preferably, both. In the Spring Term of 1970 polytechnics were newly established and, arguably, in a period of rapid change and development. Insofar as SSRs are a function of (g) (h) and (t) and these, in turn, reflect the educational strategy deployed, it might be argued that *norms* based on yesterday's behaviour were a poor guide for tomorrow's provision and that, say, national committees charged with identifying future optimum pedagogical practice, were to be preferred. However, even if it was possible to obtain a measure of agreement from academics on optimum teaching and learning environments, the resultant standardization of practice would be at odds with the British tradition in education. There is nothing particularly golden about the mean and if all institutions were forced towards it the result could well be a triumph of mediocrity.

At institutional and sub-institutional level staffing formulae provide a means of self-analysis and a guide for future action. Faced with specific staff student ratio targets they can be used internally to examine some of the cost aspects of alternative educational strategies. From such utterances as they have made on the topic this would appear to be the use that the Pooling Committee have in mind for Formula (1). This tactic of allocating resources at the centre via an overall staff student ratio and allowing institutions to discover their own roads to salvation has the merit that it allows for flexibility and, hence, creativity in teaching and learning methods at course level. Pressure in the form of staff student ratio targets may prompt a search for alternative, less labour intensive and may be educationally superior ways of achieving the learning objectives i.e., it may prove to be an effective change-agent; whereas pressure in the form specific targets for (g) (h) and (t) might well atrophy the system in the form of present, or worse, past pedagogical practice. On the other hand, Bottomly et al[12] have demonstrated that, as far as Bradford University is concerned, supporting expansion with a constant staff student ratio could result in more staff being allocated than were necessary to maintain existing average class-contact loads. Therefore, they recommended that consideration be given to using a teaching commitment rather than a staff student ratio in calculating the extra staff necessary to support the expansion of student numbers.

The Bradford exercise is particularly interesting in that it illustrates the use of staffing formulae to investigate the potential economies inherent in various educational strategies. They studied the effects of varying various parameters on cost per student via a staff cost index (SCI):-

$$SCI = \frac{\dfrac{x.M_p.100}{t.s_p}}{\dfrac{x.M_q}{t.s_q}}$$

$$= \frac{M_p.s_q}{M_q.s_p} \; . \; 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

where x = Average salary per member of staff;

M = The number of meetings = $h_{ij}.s_j/g_{ij}$ from equation (4)

s = The number of students enrolled;

p = The original situation; and

q = The new situation.

With regard to the economies arising from the expansion of students they held the pattern and types of meetings, the tuition loads, and the teaching loads constant (i.e. the *quality* of the teaching inputs to the educational process was unimpaired) and discovered that, over the eight departments investigated the SCI fell between 52 percent and 82 percent with an approximate doubling of enrolment. This result is due to the potential economies inherent in the open-ended (in terms of the numbers of full-time equivalent students) lecture. However, the extent to which a class can grow without diminishing the educational effectiveness of the teacher is a moot point. The importance of an abundance of small class teaching is nevertheless not yet proved.

'Naturally, it is harder to teach more students than it is to teach less, but the prevalent ideas about this subject are scarcely based on rational analysis. Some time ago a colleague and I studied the matter briefly and interviewed a good many teachers and other educators. We concluded that, according to our informants, the optimum size of any class is three less than are in it, and we came away with the impression that each teacher can name the three he wants out.' (13)

Some Questions Needing Answers

If an organization wishes to operate effectively and efficiently it will seek that combination of activities and allocation of resources which maximizes its objective function. To move towards this state it must, firstly, be agreed on its targets; secondly, it must be able to specify and measure its inputs, immediate outputs and ultimate impacts on the wider society; and, thirdly, it must be able to define its processes and establish the relationship between its inputs and outputs. As far as educational institutions are concerned they are some way off such a complete specification of their production function. Most of the work done so far has been in the area of inputs

Table 3

Student hours per week scheduled, group size and teaching load hours per week by subject field

Subject field	Student hours per week scheduled								Group size *							Teaching load	
									Seminar						Lecture		
		First Degree			Higher Degree				First Degree			Higher Degree			Higher Degree		
	Total	Lectures	Seminars	Observations	Total	Lectures	Seminars	Observations	Average	Maximum	Observations	Average	Maximum	Observations	Average	Average	Observations
Pure sciences	19.5	9.9	9.6	(47)	14.9	6.2	9.0	(32)	16	30	(40)	7	13	(33)	18	8.1	(61)
Technology	25.5	13.8	11.7	(33)	20.9	11.1	9.8	(21)	17	34	(17)	7	12	(13)	11	8.9	(48)
Medical sciences	24.2	12.6	11.6	(7)	19.5	11.5	8.0	(2)	16	28	(5)	5	12	(2)	-	6.2	(4)
Humanities	14.9	9.0	5.9	(35)	11.4	7.7	3.7	(23)	14	23	(16)	6	10	(13)	10	8.4	(45)
Law	19.3	15.3	4.0	(7)	16.3	11.6	4.7	(3)	15	38	(4)	-	-	(0)	-	5.9	(9)
Social sciences	17.0	12.8	4.2	(31)	12.7	9.3	3.4	(23)	17	29	(18)	10	15	(15)	15	9.2	(4)

* Evidence on the group size for first Degree lectures was scanty but suggested an average close to the average seminar size.

Source: B Fredriksen *Subject Field and Regional Variations in Student to Staff Ratios, Academic Programmes and Recurrent Expenditures* Paris CERI-OECD 1971

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and teaching processes and the major attention has focussed on the deployment of academic staff.

The academic staffing formulae discussed above have implicitly defined output in terms of (s) the numbers of full-time students. Moreover they have taken as the system's objectives either maintaining constant the academic staff cost per full-time student, or (hopefully) minimizing this cost or maximizing the full-time student throughput for a given level of academic staff expenditure. The studies have demonstrated some of the economic consequences of particular learning and teaching environments as reflected in the pattern and sizes of formal staff student meetings and teaching and tuition loads. The economic effects of the implied trade-offs between academic staff on the one hand, and technician staff, space and equipment on the other, have yet to be explored; as have the educational consequences of alternative pedagogical strategies from the traditional mix of staff supervised lectures, tutorials and laboratories at one end of the spectrum to the student-orientated programmed learning and resource-centre based environment at the other. We know that an increase in the average class size and a reduction in students' tuition loads will lead to savings in academic staff but what will be the effects on examination pass-rates, students' wastage rates and students' ultimate employability? If the quality of the educational process and its outputs is to be maintained how far would savings in academic staff need to be offset by increased investment in technician staff, library facilities and the hardware and software of educational technology? Can we identify and meaningfully categorise the alternative learning and teaching strategies? How much will they cost and what effects, if any, will they have on outputs? Can we agree on the recognition of the system's outputs? Is the output merely the number of full-time students; or is it the number of successful graduates; or yet is it the purpose of an educational institution to maximize the *learning gain* as measured, say, by the difference between points on an A-level scale at entry and class of degree at exit? Is a college effective if both its examination pass-rates and its contributions to graduate unemployment are high? We have hinted at some of the difficulties of constructing performance indicators on the educational and economic planes, how then do we begin to recognize the system's contributions on the cultural and social fronts? These are a few of the many questions which need ultimately to be answered or at least attempted.

It is likely that large parts of the system will not be susceptible to quantification in the normal sense but hopefully 'subjective judgements may be ordered and categorised even when they cannot be placed on a calibrated scale.'(14) What is important is that we attempt to sort out those areas which can be quantified to leave exposed those parts which cannot for discussion by all the interested parties. Even if we could specify the relationship between inputs and outputs precisely we would still have to make judgements on the scale of activity and the levels of resource allocation:-

'How much money should be allocated to a programme depends on what outputs and effectiveness would emerge if various amounts were to be spent - a question of fact - and on what increments in output and effectiveness the decision-makers feel are worth the extra money - a question of taste. How much output or effectiveness should be sought depends on how expenditures would change if various levels of output or effectiveness were to be sought - a matter of fact - and on which increments in expenditures the decision-maker feels are justified by the extra output of effectiveness - a matter of taste.'(15)

The staffing formulae for higher education developed in the UK in recent years have been in response, in part, to increasing pressures to cope with *more* with *less more* resources. They have examined only part of the total system and to that extent they may have come up with sub-optimal answers. However, they provide useful conceptual frameworks for further research and development. 60

The Immediate Position

The foregoing survey has attempted to trace the development of thought on performance measures in higher education. However, at this point in time, polytechnics are confronted with a problem of strategic and tactical dimensions: how to react to the Pooling Committee recommendations. Much as one may dislike or welcome the document, it seems to us that it is impossible to ignore it. At one level, its acceptance by LEAs and Governing Bodies obviously determines the global staffing which will accrue to the institution, and if one faculty is hopelessly over the top in terms of its staff student ratio, the potential for growth of other faculties is likely to be seriously curtailed. If the concept of the norm factors is accepted and investigated within an institution, the repercussions are likely to be even more profound in terms of the questioning of the way in which the learning process is set up; the deployment of staff; processes of marketing courses etc. Those who claim to be ignoring the document or dismissing it as being unworthy of attention are, in fact, doing nothing of the sort: they are merely accepting the global ratios set out (1:7.5-8.5, and 1:9.2-10.2) and not implementing anything else. Staff student ratio, of course, is not a new concept or practice, either for planning staff establishments or for control purposes. It is subject to the usual changes of *creeping incrementalism*, of course, which may be levelled against any budget based on forward projections from the status quo.

Thus, the Pooling Committee's recommendations on staff student ratio bands based on equations (1) and (2) above have caused the polytechnics to recalculate their staff student ratios according to the new formulae and to compare their positions with the *norms*. It is too early to assess the precise nature of subsequent decision-making but two distinct groups of reactions are likely - those based on problem-resolution through devices which are primarily *cost* orientated; and those based on producing more favourable cost effects through a thorough-going analysis of *educational* objectives and alternative learning strategies and teaching models. In the short-run it is probable that the former reaction will be in the ascendancy exhibiting the following characteristics:

The substitution of capital (equipment etc.) for labour.
The substitution of student initiative for staff supervision (technicians/clerical),
The substitution of low cost labour for high cost labour (teaching staff).
An increase in the intensity of labour utilization.
The non-filling of academic staff vacancies and the re-education and subsequent redeployment of staff in other related disciplines and departments.
A closer look at the efficiency of the marketing function with a possible change in priorities, e.g. a search for full time equivalent student-worthy courses and increased enrolments in low cost (in terms of academic staff) subjects.
A curtailment of the option range in courses.

In themselves, each of these are perfectly valid activities, since they attack an immediate problem by attempting to reduce staffing costs and increase student numbers, and it is arguable that polytechnics ought to have been striving after such economies anyway, with or without the stimulus of the Pooling Committee. However, in the position of reacting to an immediate problem, it would be unfortunate if precipitate action, justifiable in cost terms, neglected other significant factors. In particular:

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1. The primary aim must be to maintain and extend the academic excellence and social responsiveness of the institution.
2. Any staffing adjustments require a humane and supportive personnel policy.
3. Staff with managerial responsibilities ought to be induced with the incentive to be cost-conscious and economic in their planning and deployment of staff (consistent of course, with their educational goals). Staff who design and run courses are making various types of decisions but it is debatable whether resource consumption is a factor high in their minds. At present, there are no such incentives, and it is not the purpose of this paper to consider them. However, the notion of cost centres within departments has something to commend it.
4. To facilitate 2 and 3 there should be an increased investment in attempts to establish: a finer definition of output than the numbers of full-time equivalent students, and the extent to which it is possible to make substitution in input and the relationship between inputs and outputs.

The Future

It is one thing to tear apart the attempts to Bottomley, Delany, and others, to develop an analytical system; we are all conscious of the pitfalls. It is rather more difficult to be more constructive, and it is the contention of the authors that the problem needs to be approached thus;
establish the nature of the educational objectives of one's activities, in behavioural terms;
identify a range of alternative instructional and learning models which would enable these objectives to be fulfilled;
cost these alternatives;
select that which offered the optimum in terms of educational benefits and resource consumption.

The accompanying Appendix indicates a range of such alternatives, principally drawn from American sources,[16] and not at all complete. (It omits reference to the Keller Plan, for instance, which is finding appropriate application in the UK). Clearly, a considerable act of judgement has to be made at the conclusion of the analysis; in educational decision-making it was ever thus. However, the judgement is clearly directed primarily towards educationally-based alternatives, not cost-based alternatives.

One of the fears of the authors in the current situation is that analytical experiments will be rejected out of hand. This is disturbing for two reasons. First, it is contended that this is a process which we must go through to find out more about ourselves and what we are doing. If we can learn from these experiments and find a method that satisfies a series of acceptable criteria, a great deal will have been achieved, but the criteria needs a great deal of thrashing out first. Second, Robbins based a number of his assumptions on the management and government of higher education on the notion of the *academic self-governing community.* This involved freedom, but also responsibilities, one of which was to manage resources carefully and effectively. In the stretching of infant wings, polytechnics would be well advised not to be too arrogant or insensitive of external perceptions, by LEAs, DES etc. If we reject a whole series of planning devices, do we not have an obligation to produce one of our own? 62

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11 The Null Hypotheses that: (i) The total number of teaching hours provided for first degree students does not vary according to subject field; and (ii) The part of the total teaching scheduled as lectures for first degree students does not depend on subject field, were both rejected at the p = 0.01 level. See p 41 and p 45 *Subject Field and Regional Variations in Student-Staff Ratios, Academic Programmes and Recurrent Expenditures* B Fredriksen CERI-OECD Paris, 1971

12 Bottomly et al op cit p 123

13 J A Kershaw 'Productivity in American Schools and Colleges' in Blaug (Ed) *Economies of Education* Penguin Books, 1969

14 *Output Budgeting for the DES* Education Planning Paper No. 1 HMSO, 1970 See 4.2

15 L Merewitz and S H Sosnick *The Budget's New Clothes* Markham, 1971 p 57

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Figure 1 A SYSTEMS MODEL OF AN EDUCATIONAL INSTITUTION AND THE CONTEXT OF ORGANIZATIONAL EFFECTIVENESS

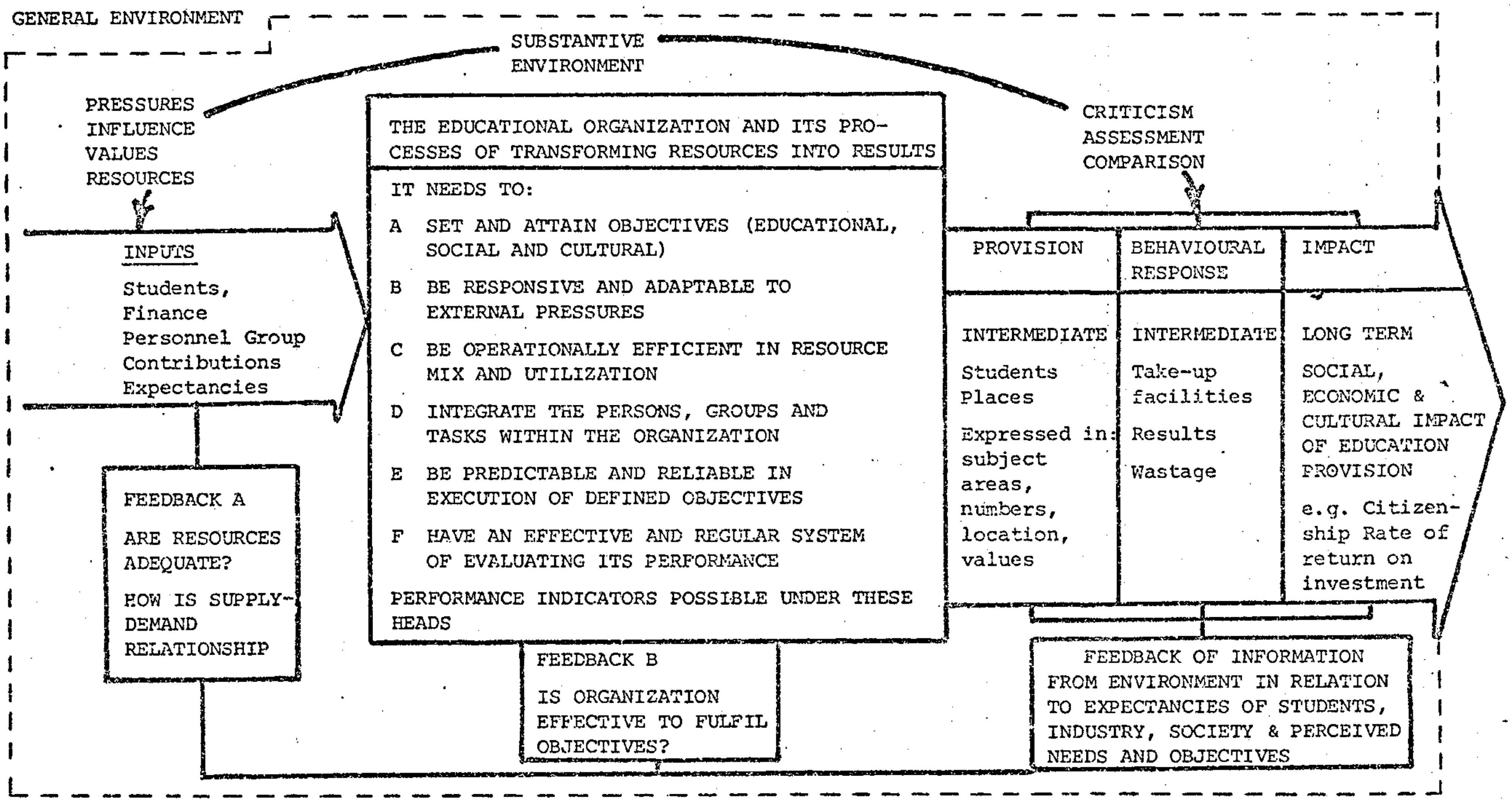

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Figure 2: Alternative instructional models

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1 *Conventional Model*

Traditional mix of lectures, tutorials, lab. work.
Common course for all students moving at same speed.
Generally: High priced labour consumption (low use of support staff).
Passive students.
Intensive for staff and students.
Capital a supplement for labour, not a substitute.
Poor use of equipment.
Quality questionable - inefficient use of individual time.
No incentive to learn.
Incentive to *pass*.
Fragmented use of time.

2 *Ruml Model*

Emphasis on large lecture groups for ½ course, supplemented by intensive tutorials.
Generally: Concentration of academic offerings into major areas of excellence.
Considerable reduction of smaller courses and options.
Labour productivity high, but also reduced loads.
Star lecturers, + *pastoral* academics + assistants (C + Burnham!) salary savings.
Capital costs lower - larger rooms
Higher utilization of teaching and library facilities.
Lower instructional costs.
Quality unclear: Complaints of large classes + impersonality.
No active encouragement of *fringe* subjects!

3 *Programmed independent study model*

Broad-frame syllabus within which student pursues tailor-made programme.
Considerable latitude for students - lecturer a resource centre/ consultant.
This would replace ½ existing curriculum.
Generally: Savings in staff.
Role change for staff.
More courses possible with same staff (?).
Less capital cost for classrooms - more for individual work space.
Considerable potential for raising quality of instruction.
Active students.
But - students unable to take responsibility rejected?
Or increased individual supervision time which would negate savings.

Figure 2: (Continued)

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4 *Bakan Model*

Compressed + unstructured curriculum + extensive use of tutorials.
Arrangement of curriculum so that tutorials used without undue cost.
Student free to select from a list of courses + develop individual plan of study per term.
Staff free to decide own role + frequency of activities, for
determining student assignments;
review progress;
evaluate results.

5 *Kieffer Model*

Creation of courses based on
programmed learning and instructors;
students selection of pace of work;
sequential phases (with instructions, assignments etc.);
learning resource centres.

Independent study base differing from 3 & 4 in that
it requires heavy preparation by staff: 1 year in advance;
staff must be experienced in learning behaviour;
major investments must be made in software and hardware;
major investments must be made in support staff;
individual staff are denied much creativity in actual operation of programmes.

Effects of increased labour productivity;
increased labour savings (by capital substitution);
more integrated courses;
maximizing learning momentum;
behavioural objectives for courses;
teaching students how to learn effectively.

Summary Instructional Model	Labour costs	Capital costs	Labour intensity	Relative labour productivity	Rel. cost of outputs	Rel. quality of outputs
Conventional	H	M	H	M	MH	M
Ruml	VH	M	H	VH	ML	M
Programmed indep. study	H	M	M	H	M	MH
Balkan	H	M	H	ML	H	MH
Kieffer	H	H	M	H	H-VH	MH

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HIGHER EDUCATION REVIEW

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A comparative timetable analysis for undergraduate programmes in a polytechnic and a university

Derek Birch and John Calvert

Teaching (unlike learning) takes place in meetings between students and academic staff. The timetable is a written record of these meetings which may be defined in terms of time, place, discipline and group size. The systematic collection and analysis of timetable data is one approach to an improved understanding of the teaching process. Doubts may be cast on the absolute accuracy of timetables but the information they contain is at least as reliable as that obtained by student/faculty questionnaires or diaries. Teaching requires academic staff commitment not only to formal classroom time but also to preparation, the correction and feedback of students' assignments, the preparation and marking of examinations and other assessments, and sundry administrative tasks. Information on these 'outside–the–classroom' activities is difficult to obtain and, when obtained, probably subjective and therefore suspect. Preparation time is likely to be a function of the level of work and of the experience of the teacher, whereas marking and feedback is a function of student numbers. If we assume that a teacher will have a mix of levels, of 'new courses', and of group sizes which does not diverge greatly from the average for his institution then the timetable provides information on faculty teaching loads. More importantly from the point of view of this paper the timetable also defines the pattern of demand for teaching space and specifies aspects of the students' formal learning environment.

The timetable analysis described below is part of an investigation into performance indices in higher education sponsored by the OECD Institutional Management in Higher Education Programme and financed by the Department of Education and Science. The study has involved

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inter alia an examination of student timetables at Lanchester Polytechnic and Loughborough University for the whole of the academic year 1972–73 for all undergraduate courses (except art at Lanchester). An analysis of who was taught, by whom and for how long has revealed some large differences between the two institutions which may have educational, cultural and social implications. Some of the economic consequences are explored below

TABLE 1

1972 enrolments to first degree courses included in the study

	Lanchester	Per cent	Loughborough	Percent
Sandwich				
Engineering and technology	716	31	1119	44
Science	181	8	235	9
Social and Business studies	398	17	125	5
Other	87	4	31	1
Full–time				
Engineering and technology	–	–	342	14
Science	361	16	332	13
Social and business studies	458	20	192	8
Other	101	4	150	6
Total	2302	100	2526	100

Source: see text

In 1972–3 the first degree populations at Lanchester and Loughborough were very similar, and the split between sandwich and full–time students in each institution was virtually identical (see Table 1). In both institutions over 90 per cent of the undergraduates were

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reading for degrees in engineering and technology, pure and applied science, or social and business studies. Within these three broad discipline areas, however the mix was different – engineering and technology (58 per cent was the dominant discipline at Loughborough, whereas at Lanchester there was a more equal balance between engineering and technology (31 per cent), social and business studies (37 per cent) and pure and applied science (24 per cent).

Timetable Parameters

Previous studies have identified average class size, average teaching load, average tuition load,[1] the mix between lectures (comparatively open–ended in terms of potential student accommodation) and small group situations (with critical maximum class sizes),[2,3] and preparation and postmortem time[4] as important variables to be included in academic staffing formulae. However, so far as we understand them these formulae have been concerned with analysis at the level of the institution and/or have viewed the 'course' as self–contained and timetabled independently. In the event, the situation particularly at Loughborough, proved to be more complex, approximating to the 'modular' structure represented in the matrix in Fig.1. In this figure, the columns represent courses and the rows subject elements. If a subject element is compulsory then the upper limit of a class size is the sum of the total enrolments to the courses taking that particular topic – for example, courses 1 and 3 for subject element A in the matrix. If a subject element is optional the enrolments to meetings in that topic will be equal to or less than the total enrolments to the courses participating.

Courses

		1	2	3
Subject Elements	A	x		x
	B	x	x	
	C		x	x

Figure 1: Diagrammatic course structure at Loughborough University

Thus a course consitutes a set of 'meetings' where a meeting is a timetabled hour of contact between academic staff and students. This set can be broken down into subsets on the basis of the department providing the tuition the type of space utilised and the size of the student groups assigned to each teacher. For a particular course this subset may be compulsory or optional, can be taught to a single course, or may involve a number of courses. Consequently, to analyse a set of meetings the following information is required:

Total enrolment to a course (denote by E)
The enrolment from a course to a particular subset of meetings (denote by s where $s \leqslant E$);
The total enrolment from all courses attending this particular subset of meetings (denote by E* where $E^* \geqslant s$);
The department providing the tuition for this particular subset of meetings;
The number of student groups each assigned to *one* teacher formed in this particular subset of meetings (denote by g); and
The total number of hours attended by a student in this particular subset of meeting(denote by h) of a particular group size (E^*/g).

From these data it is possible to define for each year of a course, for a department's courses, for discipline areas and for each institution the following values where, in each case, the summations are made over the relevant subsets.
Student's tuition load = Hours of timetabled contact with faculty that the student on average received = $\Sigma[(h)(s)]/E$
Meetings (hours) timetabled for a course = $\Sigma[(h)(g)]$
Summed over a department or discipline area or for the institution, the statistic 'meetings' counts joint meetings (ie meetings involving two or more courses) several times. Therefore, where several courses attend the same subset of meetings the timetabled hours may be allocated pro rata to the number of students attending from a course, ie:

Allocated meetings = $\Sigma[(h)(g)(s/E^*)]$

$$\text{Students' average group size} = \frac{\Sigma[E^*/g]\ [\frac{(h)(s)}{E}]}{\Sigma[\frac{(h)(s)}{E}]}$$

$$\text{Institution's average group size} = \frac{\Sigma[E^*/g]\ [(h)(g)(s/E^*)]}{\Sigma[(h)(g)(s/E^*)]}$$

TABLE 2

Summary of timetable parameters for three year undergraduate cycle 1972–73

	All disciplines		Engineering & technology		Science		Social and business	
	Lan	Lou	Lan	Lou	Lan	Lou	Lan	Lou
Students tuition Load (hrs)	1,930	1,612	2,329	1,685	2,471	1,688	1,325	1,306
Meetings (hrs)	146,086	118,468	62,217	50,394	44,067	32,884	33,378	25,475
Allocated meetings (hrs)	141,606	62,418	62,102	31,990	44,067	16,987	30,469	7,089
Students average class size	18	43	13	49	12	37	30	41
Institution's average class size	10	21	9	23	10	20	12	20

Source: see text

The results

Tables 2, 3 and 4 summarise the timetable parameters over the normal three year undergraduate cycle, the relative frequency distribution of the average students' group size and the pattern of demand for teaching space respectively.

For all the major comparable disciplines the Lanchester student had a tuition load greater than his Loughborough counterpart. The difference ranged from 783 hours over three years for science and applied science to 19 hours for social and business studies. Engineering and science and applied science students in both institutions had more teacher contact than their social sciences and humanities colleagues: a phenomenon identified by Frederickson[5] for a larger and wider sample in Europe. At Lanchester this difference was more than 1000 hours, compared with 400 hours at Loughborough.

The greatest divergence between the two institutions lay in the difference between meetings and allocated meetings. Meetings are the formal academic staff/student contact hours per annum that would be provided if each course was self–contained and timetabled independently: allocated meetings are the meeting hours actually provided: any difference arises out of joint classes involving more than one course. For example, in Social and Business Studies at Lanchester joint meetings reduced the one hour classes required from 33, 378 to 30, 469, whereas at Loughborough the reduction was from 25,475 to 7,089.

Partly as a result of joint meetings, the Loughborough undergraduate found himself in much larger groups on average than his Lanchester counterpart and experienced a wider variation of class size; this difference is particularly marked for engineering and technology. At Lanchester, students in social and business studies were on average in larger groups than their engineering and science colleagues; at Loughborough the opposite was generally the case.

In both institutions the average student spent over ten per cent of his timetable in groups of ten or below (Table 3). However, at Lanchester 66 per cent of the student's formal teacher contact was in groups of 20 or less compared with only 36 per cent at Loughborough. At Lanchester only seven per cent of the timetabled contact was in groups larger than 60; at Loughborough 26 per cent was in groups larger than 60 and 11 per cent in classes of 100 or more.

It is important to appreciate the distinction between the students' average group size (Table 2). The former identifies the average group size in which the average student finds himself, ie his typical learning environment. The latter identifies the group size the institution on average is required to provide. For example, an enrolment of 20

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TABLE 3

Relative frequency distribution of average student's class sizes 1972–73

	Lanchester		Loughborough	
Class Size	Per cent	Cumulative Per cent	Per cent	Cumulative Per cent
1–10	34	34	11	11
11–20	32	66	25	36
21–40	19	85	23	59
41–60	8	93	15	74
61–80	4	97	11	85
81–100	2	99	4	89
100+	1	100	11	100

Source: see text

students receiving one hour in a group of five, one hour in a group of ten and one hour in a group of 20 has a students' average group size of 11.7. The institution, on the other hand, provides four hours of group size five, two hours of group size ten and one hour of group size 20, ie the institution's average group size is 8.6. It is the institution's average group size which forms part of the base for the Pooling Committee's student/staff norms.

Almost 67 per cent of the demand for teaching space at Lanchester was for groups of ten or below compared with 41 per cent at Loughborough (Table 4). On the other hand, 12 per cent of the demand at Loughborough was for groups greater than 40 whereas at Lanchester only two per cent of the demand was for groups of 40+ students.[6]

TABLE 4

Relative frequency distribution of demand for teaching space 1972–73

	Lanchester		Loughborough	
Class Size	Per cent	Cumulative Per cent	Per cent	Cumulative Per cent
1 – 10	67	67	41	41
11 – 20	23	90	32	73
21 – 40	8	98	15	88
41 – 60	1	99	6	94
61 – 80	0.6	99.6	3	97
81 – 100	0.3	99.9	1	98
100+	0.1	100	2	100

Source: See text

Some economic implications

To summarise – in 1972–73 the average Lanchester student was by comparison with the Loughborough undergraduate, timetabled for 20 per cent more hours in classes of approximately half the size invariably with students from his own course. Higher tuition loads, smaller groups and a much lower incidence of joint meetings were consistently observed at Lanchester in all disciplines. What are the economic implications of these differences? A measure of the percentage 'savings' in undergraduate demands for tuition brought about by joint meetings is given by:

$$100\ (1- \frac{\text{Allocated meetings}}{\text{meetings}})$$

	Lanchester	*Loughborough*
Engineering	0.2	36.5
Science	0.0	48.3
Social and Business Studies	8.7	72.2
All disciplines	3.1	47.3

These figures indicate that where a modular structure exists involving joint meetings (whether planned or simply 'emerging' as apparently at Loughborough) the critical variable in forecasting the economic impact of 'new' courses is not necessarily the projected enrolment. If a new course can be merged for large parts of its curriculum with existing classes, its marginal demands for tuition may be minimal. During 1972–73, with very similar total enrolments to undergraduate programmes at both institutions, there were (in our survey) 49 courses at Loughborough and only 39 at Lanchester. At Loughborough the enrolments to any one year of a course ranged from one to 90 whereas at Lanchester they ranged from five to 125. However, the average class size of the sole student enrolled on a particular 'new' course at Loughborough was 57, whereas the students average class size of the course at Lanchester with an enrolment of 125 was 51! Thus whenever joint classes are a feature of a timetable the recommendations of the Pilkington Committe [7] on minimum class sizes in further education would seem to be inappropriate. Moreover, if a new course is to be timetabled jointly with existing classes for some part of its curriculum, then this factor should be taken into account by the Regional Staff

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Inspector and the Regional Advisory Council in deciding to allow recruitment to proceed in advanced further education.

Thus far we have examined the economic possibilities of joint meetings, but there are also clear differences between the institutions in class sizes and formal tuition loads. A measure which summarises the cumulative effects of these differences is:

$$\frac{\text{Allocated Meetings}}{\text{Enrolments}}$$

For 1972–73 this ratio of undergraduate tuition demands in hours per annum per student enrolled in college was as follows:

	Lanchester	*Loughborough*
Engineering	90	26
Science	81	30
Social and Business Studies	36	22
All disciplines	63	27

Thus the tuition demands are higher at Lanchester by a factor of nearly 3.5 in engineering and technology, 2.7 in science and 1.6 in social and business studies. Assuming that the preparation, marking and other out–of–class activities of the academic staff concerned are comparable across the two institutions (probably a large assumption!) it appears that in 1972–73 the average undergraduate at Lanchester made over double the tuition demands of his Loughborough counterpart. There are two possible consequences of this. If the teaching load (timetabled hours per annum) of the average full time equivalent member of the staff and his salary were similar for the two institutions, the academic staff cost per undergraduate at Loughborough would be less than half that at Lanchester. Alternatively, the average Loughborough lecturer could have half the timetable commitment, devote more time to research, so that academic staff unit costs are approximately the same in both institutions. In the event the first of these possibilities proved to be more the case.

Given an assumption that the teaching efforts of an institution are directly related to its timetable, a timetable analysis such as described above offers an alternative and, wherever service teaching and joint meetings are a feature, maybe a more accurate method of allocating costs to courses and to students than the traditional allocation on the basis of departments.[8] A cost is only valid within a particular context – different contexts will produce different costs and this is particularly so where, as in higher education, joint outputs exist. In assessing the

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performance of an institution, factors other than those discussed above need to be taken into account: the nature, quantity and quality of the outcomes of the teaching process – cultural and social as well as educational; the quality, aspirations and attitudes of the staff and students; the explicit and implicit objectives of the institution; the organisation structure and managerial climate. We have not collected information on these variables but we have collected data on A level and other entrance examination scores and subsequent examination performance. A summary of the A level scores and internal examination results for 1972–73 for both institutions has been published elsewhere.[9] Briefly, the average Loughborough student with a mean A level score of just below C was about three quarters of a grade above his Lanchester counterpart – which may be some explanation of the difference in timetables. Apart from first year failure rates (Lanchester 22 per cent, Loughborough 9 per cent), pass and wastage rates in 1972–73 were virtually identical for both institutions, and there was a consistent and similar improvement in mean scores accompanied by a tightening of the distribution of marks from second to third year studies

If differences in educational outcomes prove to be not statistically significant, the emphasis shifts from cost benefit to cost effectiveness in assessing institutional performance. In such circumstances the deployment of students and staff outlined in the timetable becomes more critical. Cross institution comparisons apart, a timetable analysis identifies some of the resource implications of alternative educational strategies and it is an obvious aid in the internal resource allocation process. The economic advantages of lower tuition loads and joint meetings leading to larger groups are easily demonstrated. The questions of the educational and cultural 'costs' involved in these teaching strategies are more demanding. We are exploring some of the educational outcomes – the effects on the ethos and social climate of the institution remain a potentially fruitful area for research.

Notes

1 Delany, V J (1971), *Cost Efficiency Indicators in Further Education*, The Association of Colleges of Further and Higher Education.

2 Bottomley, J A et al (1972), *Costs and Potential Economies*, OECD/CERI/IMHE, Paris.

3 Legg, K (1971), *Comparative Studies in Costs and Resource Requirements for Universities*, OECD/CERI/IMHE, Paris.

4 Simpson, M G et al (1971), *Planning University Development*, OECD/CERI/IMHE, Paris.

5 Frederiksen, B (1971), *Subject Field and Regional Variations in Student/Staff Ratios. Academic Programme and Recurrent Expenditures*, OECD/CERI/IMHE, Paris.

6 We have also collected and analysed data for both institutions for the academic year 1973–74. There were no significant changes between the 1972–73 and 1973–74 timetables.

7 Pilkington Committee on the More Effective Use of Technical College Resources (1966), *Size of Classes and Approval of F E Courses*, HMSO.

8 See Birch, D W, Calvert, J R and Sizer J, 'A Note on Costing The Teaching Activity in Higher Education', to be published in forthcoming edition of *Higher Education.*

9 Birch D W, Calvert, J R and Sizer, J (1976), 'A Study of Some Performance Indicators in Higher Education with Particular Reference to Lanchester Polytechnic and Loughborough University', a paper presented to the Third General Assembly of Member Institutions IMHE/CERI/OECD, Paris. Mimeographed, available from the authors.

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COMPARATIVE UNDERGRADUATE UNIT COSTS IN A UNIVERSITY AND A POLYTECHNIC

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"Far from there being any one single definitive concept of costs, there are a number of concepts, all equally valid in their own contexts. A generally acceptable definition of historical costs would be actual expenditure on non-capital items recorded by the accounting system plus that proportion of capital outlays past and present which it is deemed appropriate to set against current outputs and which may or may not be recorded by the accounting system plus opportunity costs.

An example of unrecorded expenditure is depreciation. The most widely cited instance of opportunity cost in higher education is the income forgone by the student, or, from society's point of view, the loss of Gross National Product occasioned by the withdrawal from the work force of a student of employable age. As soon as we venture outside the concept of cash flow into concepts of depreciation and opportunity costs we move from questions of fact into questions of opinion. These costs are what is forgone by devoting resources in a particular way rather than the most profitable way, and in the conditions of uncertainty in which we have to operate we have no way of identifying the most profitable alternative and, therefore, we have no way of discovering 'the cost'.

However, I intend to speak about costs recorded by the accounting system only, and hence am on surer ground. Nevertheless, the way in which these costs are allocated to the joint outputs of higher education - teaching, research and public service - is an arbitrary process subject to debate.

The comparative costing study which I shall describe is not yet completed, and therefore the material should be treated as partial. The study is of Lanchester Polytechnic and Loughborough University, and is based on 1972/73 data. It is part of an OECD/CERI Institutional Management in Higher Education programme called "The Development of Performance Indices for the Teaching Function of Higher Education".

The objectives of the study are:

1. to identify and define the inputs, outcomes and processes of the teaching function;
2. to collect data and measure as far as possible the variables and parameters identified in 1 ; and
3. to establish sets of performance indicators and to investigate their use as planning and control mechanisms.

We have probably achieved the first and second objectives, but are a long way from achieving the third.

The components of the teaching function which we considered are identified in Figure 1, which shows the objectives of the institution, some set internally, some given by the environment, the inputs, processes and outcomes. Within the constraints of the project's budget and two year time scale it was not possible to collect and analyse data on all the components identified. Accordingly the focus was on those aspects for which data was most readily available and quantifiable. It was decided not to collect data on:

1. the students' socio-economic backgrounds or their attitudes and expectations at entry and exit;
2. the 'quality', expectations and values of staff;
3. the management structure and process; and
4. the long term impacts of higher education.

While these variables were thought significant, the collection and analysis of information on each would not have been possible within the projects' budget and time constraints.

Information was collected primarily for the directly comparable parts of the institutions, i.e. the first degree programmes.

Table 1 gives details of the numbers of students enrolled on study programmes included in the investigation. Sandwich students on these courses who spent the whole of the academic year 1972/73 out of college at practical training are omitted. The total numbers involved in each institution are very similar and the split between sandwich and full time in each institution is virtually identical. In both institutions the large majority of students are to be found in either technology and engineering, pure and applied science, or social and business studies. However, within these three discipline areas the mix is different: engineering and technology (58%) is

FIGURE 1

COMPONENTS OF THE TEACHING SYSTEM

OBJECTIVES
Educational
Economic
Cultural
Social

INPUTS:

(i) Students: knowledge, skills, aptitudes, attitudes, expectations at entry: socio/economic background.

(ii) Staff: Academic, pedagogical, administrative technical, managerial competence and experience; Expectations.

(iii) Physical Facilities: space, equipment:- learning, teaching, cultural, recreational.

PROCESSES:

(i) The Curriculum/Learning Environment: The pattern of formalised "meetings", teaching and tuition loads; pedogogical strategies and tactics - e.g. from traditional mix of staff supervised lectures, tutorials and labs at one end of the spectrum to student orientated programmed learning and resource centre based environment at the other.

(ii) The Assessment/Licensing mechanisms/criteria: assignments, tests, exams etc.

(iii) The "Organisation": Management structure + process, "style", + "ethos", etc.

→

(i) Immediate: Provison of learning opportunities: "Places" on an organised curriculum. Response = applications → Enrolments

(ii) Short Term: Graduates Students: knowledge, skills, aptitudes, attitudes, expectations at exit.

(iii) Longer Term: Impacts on GNP/Life time Earnings; Cultural and Social dimensions.

TABLE 1

1972/73 ENROLMENTS TO STUDY PROGRAMS INCLUDED IN PROJECT SURVEY

	LANCHESTER						LOUGHBOROUGH				
DISCIPLINE:	Year 1	Year 2	Year 3	Year 4	TOTAL	%	Year 1	Year 2	Year 3	TOTAL	%
Sandwich											
Education	-	-	-	-	-	-	22	7	2	31	1.2
Technology & Engineering	270	234	212	-	716	31.1	549	313	257	1119	44.3
Science & Applied Science	72	60	49	-	181	7.8	87	84	64	235	9.3
Social & Business Studies	133	130	127	8	398	17.3	72	24	29	125	5.0
Urban & Regional Planning	24	23	19	21	87	3.8	-	-	-	-	-
Librarianship	-	-	-	-	-	-	-	-	-	-	-
Languages Studies	-	-	-	-	-	-	-	-	-	-	-
TOTAL	499	447	407	29	1382	60.0	730	428	352	1510	59.8

TABLE 1 cont.	LANCHESTER						LOUGHBOROUGH				
	Year 1	Year 2	Year 3	Year 4	TOTAL	%	Year 1	Year 2	Year 3	TOTAL	%
Full Time											
Education	-	-	-	-	-	-	-	-	-	-	-
Technology & Engineering	-	-	-	-	-	-	148	100	94	342	13.5
Science & Applied Science	150	103	108	-	361	15.7	127	108	97	332	13.1
Social & Business Studies	182	147	129	-	458	19.9	103	56	33	192	7.6
Urban & Regional Planning	-	-	-	-	-	-	-	-	-	-	-
Librarianship	-	-	-	-	-	-	29	21	15	65	2.6
Languages Studies	38	33	30	-	101	4.4	39	19	27	85	3.4
TOTAL	370	283	265	-	920	40.0	446	304	266	1016	40.2
OVERALL	869	730	674	29	2302	100.0	1176	732	618	2526	100.0

clearly the most popular discipline at Loughborough whilst at Lanchester there is a more equal balance between engineering and technology (31%) social and business studies (37%) and pure and applied science (24%). The budgets for both institutions are roughly comparable, once they have been adjusted appropriately, for example by taking out the debt charges from Lanchester and commissioned research income from Loughborough. By far the largest expenditure, two thirds of the total budget, went on academic staff in both institions.

There have been a number of previous attempts to identify the tuition demands in institutions of higher education. The Robbins Report and subsequently Delany(1) suggested that the important parameters were given by the number of full time equivalent students the average group size, the tuition level of the average student, and the average teaching load of the average member of staff. Thus:

$$T = \frac{\frac{s}{g} \cdot h}{t}$$

where s = number of full time equivalent students

g = average group size

h = tuition load (hours per annum of average student

t = average teaching load (hours per annum) of average member of staff

T = number of full-time equivalent staff required

Dr Legg improved on this formula. To grossly oversimplify he said that the group size was not an important parameter as far as lecture-type meetings were concerned. Therefore h, the average tuition load, could be split into the hours in lectures k and the hours in seminars m where the group size did matter.

Thus h = k + m and :

$$T = \frac{k + \frac{s}{g} \cdot m}{t}$$

where k = hours in lectures

m = hours in seminars

A study at Lancaster University (2) noted that the above formula took no account of preparation and post-mortem time and suggested that:

$$T = \frac{k(1+p) + \frac{s}{g} \cdot m(1+\frac{q}{r}) + s\,u}{t}$$

where p = average preparation time (hours) for lectures

q = average preparation time (hours) for seminars

r = number of seminar repeats

u = average amount of post-mortem time per student (hours)

Preparation time will be a function of the level of

(1) Delany V.J. (1971). Cost Efficiency Indicators in Further Education Association of Colleges in Further and Higher Education and (1972) Pooling Committee Assessment of Curricular Activity and Utilisation of Staff Resources in Polytechnics and College of FE Councils and Education Press.

(2) Simpson M.G. et al (1971) Planning University Development OECD/CERI/IMITE Paris.

work and the "experience" of the lecturer and post-mortem time will be a function of the number of students. However reliable data on these variables is difficult to obtain. If it is assumed that a lecturer will have a mix of levels, of "new courses" and of group sizes which does not diverse greatly from the average for his institution then his total teaching commitment will be directly proportional to his timetabled class contact.

A course constitutes a set of meetings where a meeting is a timetabled hour of contact between academic staff and students. This set can be broken down into sub-sets on the basis of the department providing the tuition and the size of the student groups each assigned to one teacher formed. For a particular course this sub-set may be compulsory or optional, can be taught to a single course or may involve a number of courses. Consequently to analyse a timetable the following information is required:-

(i) Total enrolment to a study program (denote by E);
(ii) Enrolment from a study program to a particular sub-set of meeting (denote by s where $s \geq E$);
(iii) Total enrolment from all study programs attending this particular sub-set of meetings (denote by E* where $E^* \geq s$);
(iv) Department providing tuition for this particular sub-set of meetings;
(v) Type of 'space' utilised by this particular sub-set of meetings - specialist/non specialist;
(vi) Number of student groups each assigned to one teacher formed in this particular sub-set of meetings (denote by g); and
(vii) Total hrs/annum attended by a student in this particular sub-set of meeting of a particular group size E*/g. (denote by h).

With this information the following values can be established:

(i) Student load = $\dfrac{\sum (h.s)}{E}$
(ii) Total meetings timetabled for a particular study program: $= \sum (h.g)$
Summed over a department or discipline area or an institution this statistic counts "joint" meetings several times, hence:-
(iii) Allocated meetings $= \sum (h.g \; \dfrac{S}{E^*})$
Hence, where several study programs attend the same set of meetings (i.e. $E^* > s$) the teaching hours were allocated pro rata to the number of students attending from a study program.
(iv) Student's average group size

$$= \frac{\sum \frac{E^*}{g} \cdot (\frac{h.s}{E})}{\sum (\frac{h.s}{E})}$$

(v) Institution's average group size

$$= \frac{\sum \frac{E^*}{g} \cdot \; (h.g. \frac{s}{E^*})}{\sum (h.g. \frac{s}{E^*})}$$

Briefly, on the basis of the 1972/73 timetables over the normal three year first degree cycle an undergraduate at Lanchester received 1931 hours of timetabled tuition as compared with 1612 at Loughborough (Table 2). The greatest divergence between the two institutions was the difference between meetings and allocated meetings. Meetings are the hours of formal timetabled tuition which the instituion would have to provide if each course was timetabled seperately: allocated meetings are the meeting hours actually provided: any difference arises out of joint meetings involving more than one course. In both institution 10% of the average students' tuition load was in groups of 10 or below, but the average class size for a first year undergraduate was 31.4 at Lanchester and 66.9 at Loughborough. The institution's average group size was 13.6 at Lanchester and 27.2 at Loughborough. To summarise, by comparison with Loughborough the situation at Lanchester Polytechnic was characterised by higher tuition loads, smaller classes and a much lower incidence of joint meetings.

Given an assumption that, the teaching efforts of an institution are directly related to its timetable, a timetable analysis such as described in Table 2 offers a basis for the allocation of academic staff costs to courses and to students. On the other hand, some part of the cost relates directly to enrolments - student recruitment for example. Accordingly, we have apportioned costs firstly, on the basis of enrolments and, secondly, on the basis of allocated meetings.

Specifically if we denote:

enrolment to a study programme by E;
enrolment to all the courses in a department by E_D;

departmental cost by C;
allocated meetings from a department to a course by M:
allocated meetings from a department to all courses by M_T;

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TABLE 2

SOME TIMETABLE STATISTICS 1972/73

	LANCHESTER				LOUGHBOROUGH		
	Year 1	Year 2	Year 3	Year 4	Year 1	Year 2	Year 3
Enrolment	845	730	674	29	963	731	618
Student Load (hours)	655	692	584	378	578	593	441
Meetings	42459	51672	51964	1864	46368	41046	31054
Allocatable Meetings	40794	50349	50473	1864	20443	22623	19352
Students' Average Group Size	31.4	19.6	18.2	16.2	66.9	46.2	28.6
(Standard Deviation)	(27.3)	(22.4)	(22.7)	(7.7)	(61.9)	(28.5)	(22.3)
Institutions' Average Group Size	13.6	10.0	7.8	5.9	27.2	19.1	14.1
(Standard Deviation)	(15.5)	(9.8)	(9.0)	(7.8)	(32.8)	(22.7)	(14.3)

the proportion of cost allocated to a department's students on the basis of enrolment by α;
the proportion of cost allocated on the basis of allocated meetings by β:
(Thus $1 - (\alpha + \beta)$ is the proportion of cost assigned to research and other activities not associated with the teaching function)
then for a course the cost is given by

$$\alpha\left(\frac{E}{E_D} \cdot C\right) + \beta\left(\frac{M}{M_T} \cdot C\right) + \left(\sum_{\substack{\text{other}\\ \text{depts.}}} \beta \frac{M'}{M_T} \cdot C'\right)$$

and if β is the same for all departments by

$$\alpha\left(\frac{E}{E_D} \cdot C\right) + \beta\left(\sum_{\substack{\text{all}\\ \text{depts}\\ i}} \frac{M_i}{M_{Ti}} \cdot C_i\right)$$

and unit cost by

$$\left[\alpha\left(\frac{E}{E_D} \cdot C\right) + \beta\left(\sum_{\substack{\text{all}\\ \text{depts}\\ i}} \frac{M_i}{M_{Ti}} \cdot C\right)\right]\left[\frac{1}{E}\right]$$

The direct outlays for both institutions in 1972/73 are set out in Table 3 on page 163.

The total enrolments and allocated meetings are given in Table 4 on page 163.

The costs have been allocated on the basis of first enrolments ($\alpha = 1; \beta = 0$) and, second, meetings ($\alpha = 0; \beta = 1$). In the latter case we have assumed that β is the same for all departments. No apportionment to non teaching activities has been made.

The 1971 "Enquiry into the use of Academic Staff Time" commissioned by the Committee of Vice-Chancellors and Principals produced inter alia the following information:

Staff paid wholly or partly from general university funds: proportion of total working time:-

	Loughborough	All Universities
Undergraduate time	36	37
Graduate course work time	8	5
Graduate research time	7	6
Personal research time	19	24
Unallocatable internal time	18	18
External professional time	12	11
	100	100

The information was collected by means of diaries maintained by lecturers. It would seem that an allocation of 20% to 30% to non teaching activities would appear conservative. However it might be argued that polytechnics and universities are primarily teaching institutions and that the teaching activity should bear the full costs and that non-teaching activities are merely a "gloss" or "bonus"! Whatever assumption is made the resulting arithmetic amounts simply to an adjustment of the full cost results by the agreed proportion.

TABLE 3

	LANCHESTER	LOUGHBOROUGH
	£'000s	£'000s
Academic Staff	1830	1284
Departmental Administrative Staff	60	120
Technician Staff	294	323
Departmental recurrent expenditure on teaching materials etc.	170	154
	2354	1881

TABLE 4

TOTAL ENROLMENTS AND ALLOCATED MEETINGS 1972/73

	U/G	P/G	OTHER	SHORT COURSES	TOTAL
ENROLMENTS					
Lanchester	2599	35	2150	996	5780
Loughborough	2660	574	-	1238	4472
ALLOCATED MEETINGS					
Lanchester	137,731	1,963	63,581	1,256	204,531
Loughborough	65,862	52,697	-	14,611	133,170

Notes: In calculating the allocated meetings:

(1) for sandwich undergraduates 10 hours per student has been allowed for industrial training supervision; and

(2) for postgraduate research students personal supervision on a one to one basis has been provided for as follows:
150 hrs p.a. for full-time students.
75 hrs p.a. for part-time students.

Table 5 sets out the unit costs for the main undergraduate areas on the basis that polytechnics and universities are essentially teaching institutions.

TABLE 5

COST £'s PER STUDENT PER ANNUM

	LANCHESTER		LOUGHBOROUGH	
	Enrolment Basis	Meetings Basis	Enrolment Basis	Meetings Basis
Undergraduates				
Engineering	476	930	375	411
Science	575	773	489	381
Social Studies	328	380	489	313
All U/gs.	457	667	430	399

An allocation soley by enrolments (where a one day short course student is counted equally with a full time student) dist ts the cost picture. Since each student involves documentation there may be a case for allocating a small proportion of the total cost (or maybe a larger proportion of the administrative staff costs) by this method. However, the allocated meetings are indicative of the "weights" the institution is implicitly assigning to its study programme.

When comparing average costs across institutions some adjustment for the discipline mix should be made. Engineering and science were the most expensive disciplines in both institutions and accounted for about 75% of the total first degree enrolment at Loughborough compared with about 55% at Lanchester. Therefore, if a discipline mix adjustment had been attempted, the apparent undergraduate cost advantage of Loughborough would have been enhanced. Whichever method of cost allocation is used the difference in costs between the major disciplines was smaller at Loughborough: because of the high incidence of joint meetings across disciplines.

Predictably the average undergraduate unit costs increase as the years of a study programme proceed: at Lanchester from £572 for first year undergraduates to £887 for third year students, and at Loughborough from £310 to £451. Hence in both institutions the final year undergraduate cost about half as much again as the "fresher". This result reflects the fact that although in both institutions the finalist had a lower tuition load this was outweighed by much reduced average class sizes and, in the case of Loughborough, fewer joint meetings.

The components of the undergrauate unit cost are given in Table 6. The technician and "recurrent" components were roughly equivalent. Loughborough enjoyed an advantage in the provision of administrative support but this only accounted for a small proportion of the total cost. The major difference between the two institutions was in academic staff input which was higher at Lanchester irrespective of the method of allocation.

The question of which is the cost of a student does not admit of one answer. The boundaries of the task have been narrowed by concentrating on teachers and their administrative, technician and 'materials' support. The problems of measuring and assigning capital expenditure and identifying opportunity costs have been thus avoided. Further, it has been assumed that polytechnics and universities are solely teaching establishments and that the outcome of this activity is students rather than graduates. Finally average and not marginal costs have been examined. In assessing institutional performance a range of criteria other than cost ought to be taken into account. In times of economic stringency and in the absence of a clear specification of the education production function the emphasis inevitably shifts to cost effectiveness rather than cost benefit. In this restricted context I believe a cost allocation on the basis of a timetable analysis adequately reflects the direction and intensity of an institution's teaching efforts."

TABLE 6

COMPONENTS OF UNDERGRADUATE UNIT COST 1972/73

	LANCHESTER		LOUGHBOROUGH	
Enrolment Basis	£	%	£	%
Academic Staff	362	79	298	69
Administrative Staff	11	2	28	7
Technician Staff	51	11	70	16
Recurrent Expenditure	33	7	34	8
	457	100	430	100
Meeting Basis				
Academic Staff	519	78	273	68
Administrative Staff	16	2	26	7
Technicians Staff	85	13	67	17
Recurrent Expenditure	47	7	33	8
	667	100	399	100

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A NOTE ON COSTING THE TEACHING ACTIVITY IN HIGHER EDUCATION

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ABSTRACT

This note explains one method of calculating unit costs for the teaching function in higher education. A formula is developed for allocating expenditures on the basis of a timetable analysis and tested on data from Lanchester Polytechnic and Loughborough University for the academic year 1972/73.

Introduction

This note arises out of an investigation into performance indicators in higher education sponsored by the Institutional Management in Higher Education Programme of OECD and partly financed by the Department of Education and Science. The data base for the case study is formed from the undergraduate courses (except art) at Lanchester Polytechnic and Loughborough University for the academic year 1972/73.

In 1972/73 the total undergraduate population at Lanchester and Loughborough was very similar and the split between sandwich and full-time students in each institution was virtually identical. In both institutions over 90% of the students were reading for degrees in either engineering and technology, pure and applied science or social and business studies. However within these three discipline areas the mix was different: engineering and technology (58%) was the dominant discipline at Loughborough reflecting the university's original raison d'être; at Lanchester there was a more equal balance between engineering and technology (31%) social and business studies (37%) and pure and applied science (24%).

A Timetable Analysis

The question of concern here is: How should the costs identified as belonging to the teaching function be allocated to courses, and ultimately, to the students taking these courses?

At the moment there is no elegant way of handling the problem – any approach is to some extent arbitrary. The largest input is invariably academic staff and a case can be made for having the allocations done by the academics themselves (NCHEMS at Wiche, 1971). Succinctly the objections that can be raised to this questionnaire/diary solution are concerned with time scales, the validity of the data and the costs of collection. Questionnaires rely heavily on the goodwill and co-operation of staff and involve a significant investment of their time. Therefore "if it is accurate and current, data that is available from other sources should be obtained from these sources and should not be sought from faculty members" (NCHEMS at Wiche, 1971, p. 45).

Teaching takes place in meetings between faculty and students. The large majority of these meetings are set down in the timetable which thus defines what? when? where? by whom? and for whom? The analysis of timetable data is an alternative method of identifying the direction and intensity of an institution's teaching efforts and, therefore, an alternative basis for cost allocation. (Bottomley et al., 1972; Delany, 1971).

Specifically, a course constitutes a set of meetings where a meeting is a timetabled *hour* of contact between academic staff and students. This set can be broken down into subsets on the basis of the department providing the tuition and the size of the classes each assigned to one teacher. For a particular course this subsect may be compulsory or optional, can be taught to a single course or may involve a number of courses. Consequently to analyse a set of meetings the following information is required:

- total enrolment to a course (denote by E);
- the enrolment from a course to a particular subset of meetings (denote by s, where $s \leqslant E$);
- the total enrolment from all courses attending this particular subset of meetings (denote by E^*, where $E^* \geqslant s$);
- the department providing the tuition for this particular subset of meetings;
- the number of groups each assigned to one teacher formed in this particular subset of meetings (denote by g); and
- the hours per annum attended by a student in this particular subset of meetings (denote by h).

Table I gives the overall results of a timetable analysis for each year of the normal three year undergraduate cycle at Lanchester and Loughborough in 1972/73.

Briefly, by comparison with the Loughborough undergraduate the Lanchester student was on average timetabled for 20% more hours invariably

TABLE I

Some Undergraduate Timetable Statistics 1972/73

	Lanchester			Loughborough		
Year of Study	1	2	3	1	2	3
Student's Tuition Load (Hours)[1]	654	692	584	578	593	441
Meetings (Hours)[2]	42 459	51 672	51 964	46 368	41 046	31 051
Allocated Meetings (Hours)[3]	40 784	50 349	50 473	20 443	22 623	19 352
Student's Average Class Size[4]	31	20	18	67	46	29
Institution's Average Class Size[5]	14	10	8	27	19	14

1 Student's Tuition Load: the hours of timetabled contact with faculty that the student on average received = $(h \cdot s)/E$

2 Meetings timetabled for a course = $\Sigma\,(h \cdot g)$;

3 Summed over a department or discipline area or for the institution the statistic "Meetings" counts joint meetings (i.e. meetings involving two or more courses) several times. Hence where several courses attend the same subset of meetings the timetabled hours may be allocated pro rata to the number of students attending from a course; thus Allocated Meetings = $\Sigma\,(h \cdot g \cdot s/E\cdot)$;

4 Student's Average Group Size = $\dfrac{\sum E^*/g \left[\dfrac{h \cdot s}{E}\right]}{\sum \left[\dfrac{h \cdot s}{E}\right]}$.

5 Institution's Average Group Size = $\dfrac{\sum E^*/g \left[\dfrac{h \cdot g \cdot s}{E^*}\right]}{\sum \left[\dfrac{h \cdot g \cdot s}{E^*}\right]}$

In each case the summations are made over the relevant subsets.

with students from his own course in classes of approximately half the size. Higher tuition loads, smaller classes and a lower incidence of joint meetings was consistently observed at Lanchester in all disciplines. However, the greatest divergence between the two institutions lay in the difference between "meetings" and "allocated meetings". The meetings are the staff-student contact hours per annum that would have to be provided if each course was timetabled independently; the allocated meetings are the class hours actually provided: any difference arises out of joint meetings involving more than one course.

What are the economic implications of these differences? A measure which summarises the cumulative effects of tuition loads, class size and the incidence of joint meetings is:

$$\frac{\text{Allocated Meetings}}{\text{Enrolments}}$$

In 1972/73 this ratio of undergraduate timetable demands in hours per annum per student enrolled in each discipline area was:

	Lanchester	Loughborough
Engineering and Technology	87	22
Pure and Applied Science	81	30
Social and Business Studies	36	22
All undergraduates	62	25

Thus the average undergraduate at Lanchester made over double the tuition demands of his Loughborough counterpart. If the class contact of the average teacher and his salary had been equivalent across the two institutions the academic staff cost per undergraduate at Loughborough would have been less than half that at Lanchester. Alternatively, the average Loughborough lecturer had half the timetable commitment, hopefully devoted more time to research and the teacher unit costs were approximately the same in both institutions.

Unit Costs

To recap, an analysis of the timetable such as described above offers an alternative and, wherever extensive inter-departmental "servicing" and joint meetings are a feature, maybe a more accurate method of allocating costs to courses than a questionnaire/diary approach or a multi-regression approach such as that of Layard and Verry (1975). Specifically if we denote:

allocated meetings from a department to a course by M; and
allocated meetings from a department to all courses by M_T; and
departmental costs by C;

then for a course the cost is given by:

$$\sum_{\substack{\text{all departments} \\ i}} \left[\frac{M_i}{M_{Ti}} \cdot C_i \right] = K$$

and unit cost by $K\,[1/E]$
where E is the enrolment to the course.

In the following tables the costs allocated include the salaries, superannuation and national insurance of academic, technician and administrative staff deployed at the level of the school (or faculty) and department together with recurrent expenditure on teaching materials, the maintenance and hire of teaching equipment, and the cost of short courses and field work. The costs for the full-time staff have been established by reference to salary scale mid points in 1972/73; the costs for part-time staff are actual. Full-time research workers financed wholly by research grants and contracts have been excluded. In the case of Lanchester the permanent Deans' salaries have been apportioned equally between the departments for which they were responsible.

Table II sets out the costs per enrolled student in 1972/73 for the major undergraduate discipline areas. In Tables II, III and IV the costs per course have been summed over the relevant discipline area and level and divided by the total enrolments to the courses in this discipline and level.

TABLE II

Costs in £'s per Undergraduate Enrolled 1972/73

Year of Study	1	2	3	Average
Engineering and Technology				
Lanchester	851	1161	1405	930
Loughborough	330	448	380	411
Science				
Lanchester	555	966	1107	773
Loughborough	291	384	592	381
Social and Business Studies				
Lanchester	364	430	372	380
Loughborough	215	379	460	313
All Undergraduates				
Lanchester	572	797	887	667
Loughborough	310	438	451	399

When comparing average costs across institutions some adjustment for discipline mix should be made. Engineering and science were the most expensive disciplines in both institutions and accounted for about 75% of the total first degree enrolments at Loughborough compared with about 55% at Lanchester. Therefore if a discipline mix adjustment had been attempted the apparent undergraduate cost advantage of Loughborough would have been enhanced. The difference between the disciplines was smaller at Loughborough because of the high incidence of joint meetings across disciplines. Predictably the costs per enrolled student increase as the years of study proceed at Lanchester from £572 for first year undergraduates to

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£887 for third year students, at Loughborough from £310 to £451. Hence in both institutions the final year undergraduate costs about half as much again as the "fresher". This reflects the fact that although in both institutions the finalist had a lower tuition load this was outweighed by much reduced class sizes, and in the case of Loughborough, fewer joint meetings. In both institutions there was some evidence that resources were being channeled to the higher level courses, at Loughborough the average annual cost per postgraduate on a meetings basis was £1147 and at Lanchester the cost per student enrolled on a sub degree course was £264.

The components of the average cost per student enrolled in 1972/73

TABLE III

Components of Cost per Enrolled Undergraduate in £'s

	Lanchester	(%)	Loughborough	(%)
Academic Staff	519	78	273	68
Administrative Staff	16	2	26	7
Technician Staff	85	13	67	17
Recurrent Expenditure	47	7	33	8
Total	667	100	399	100

TABLE IV

Cost per "Successful"* Undergraduate in £'s

Year of Study	1	2	3
Engineering and Technology			
Lanchester	1246	1372	1432
Loughborough	374	507	401
Science			
Lanchester	873	1133	1173
Loughborough	350	431	627
Social and Business Studies			
Lanchester	448	458	381
Loughborough	241	427	468
All Undergraduates			
Lanchester	792	896	914
Loughborough	374	496	472

* "Successful" = the students who successfully sat the examinations in the given year.

are presented in Table III. The technician and "recurrent" components were roughly equivalent. Loughborough enjoyed an advantage in the provision of administrative support but this only accounted for a small proportion of the total cost.

Table IV provides details of the cost per "successful" undergraduate in each year of the three year cycle by discipline area. Given a somewhat higher attrition rate at Lanchester the economic advantage of Loughborough is widened at this stage of costing. On the other hand the Lanchester students started from a lower pre-entry (A-level) score on average and the learning gain there may be higher.

Summary

The question of what is the cost per student does not admit of a single answer. Therefore it is prudent to summarise the context in which the unit costs above were derived. Firstly, the costs allocated were those for the faculty and their administrative, technician and "materials" support – the problems of measuring and assigning capital expenditure and of identifying opportunity costs were thus avoided. Secondly it was argued that the timetable reflects the "weights" the institution is implicitly assigning to its courses and that "allocated meetings" are a fair basis for the assignment of inputs to courses and to students. Thirdly, it was assumed that polytechnics and universities are solely teaching establishments. If it is accepted that higher education institutions have functions other than teaching, the trade-offs between teaching and these other roles need to be examined. If the mix of teaching to non-teaching activities is roughly equivalent across institutions then student cost comparisons as outlined above provide a reasonable guide to relative effectiveness. On the other hand, if the involvement in non-teaching varies significantly from institution to institution then consideration has to be given to unscrambling the joint costs and products. The probability is that decisions in this area will continue to require the exercise of subjective judgement and it is a moot point whether the benefits from having more sophisticated data available would justify the costs of obtaining this information.

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RESEARCH REPORT

A CASE STUDY OF SOME PERFORMANCE INDICATORS IN HIGHER EDUCATION IN THE UNITED KINGDOM

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ABSTRACT

The major purpose of this case study was to explore the potential for performance indicators for the teaching function in higher education. A framework for performance assessment in terms of "response" to the learning opportunities provided and "resource utilisation" is developed and tested on data from Lanchester Polytechnic and Loughborough University for the academic year 1972/73. At a "discipline" level of aggregation few significant differences in response but quite different patterns of instruction leading to very different unit costs are identified. The study concludes that there is a case for the systematic collection of data on instruction and resource utilisation patterns within and across institutions. However, in the absence of an accurate specification of cause and effect such a data base would require careful and sympathetic interpretation pending the development of finer measurements of outcome.

INTRODUCTION

Universities and Polytechnics pursue a number of objectives other than teaching but a consideration of research and scholarship and public service was outside the project's remit. Moreover, the research was constrained to take account of only those aspects which could be "easily quantified" and for which information was "readily available".

The data base for the case was formed from the undergraduate courses at Lanchester Polytechnic and Loughborough University of Technology for the academic year 1972/73. In that year the total first degree population at Lanchester and Loughborough was similar and the split between sandwich and full-time students in each institution was virtually identical. In both institutions over 90% of the undergraduates were reading for degrees in either engineering and technology, pure and applied science, or social and business studies. Within these three broad discipline areas, however, the mix was different - engineering and technology (58%) was the dominant discipline at Loughborough whereas at Lanchester there was a more equal balance with the highest recruitment to social and business studies (37%) (Birch, Calvert, Sizer, 1976).

A FRAMEWORK FOR PERFORMANCE ASSESSMENT

An organisation is effective if it achieves its objectives; it improves its efficiency if it achieves these objectives with fewer resources. Hence performance assessment involves (inter alia) firstly, comparing the level and quality of outcomes with objectives and, secondly, examining input-output relationships. (An institution may be internally effective yet externally ineffective if its objectives are not congruent with the needs of society.)

So apparently, the first critical task is to establish a set of objectives, but it has been argued that university objectives are not only ambiguous but are destined to remain so since both faculty and administrative staff feel this to be beneficial (Cohen and March, 1974). One problem is the lag between the process and its effects, another is the uncertainty about the nature of the connection. Whether higher education's role is conceived in terms of a capital goods industry (Schultz, 1963) or, more liberally, to include the social and cultural dimensions, or simply as a filtering device signalling ability differences which existed before the process began (Arrow, 1973) its ultimate impacts are long term and obscure. Institutional performance assessment requires more proximate objectives.

All is not lost however if we accept the inevitability of the generality and vagueness of objectives in education. It is possible to move directly to the measurement of "outputs" or (perhaps more exactly) "outcomes" and, hopefully, the evidence collected will lead to an improved understanding of, and sensitivity to, the sophistication of the educational process.

Given that institutions of higher education exist in their teaching roles to provide sets of learning opportunities and that students may choose to enrol or not, the first indication of success is provided by the numbers and "quality" of students actually enrolled. Subsequently institutions hope to progress their students successfully through the system and ultimately to have their graduates accepted by the economy. Hence, dropouts, failures, repeaters, successes, graduates and the initial employments of graduates are all outcomes of various stages of the educational process and a careful monitoring of these is indicated. Inherent in the success rate criteria is the view that the institution may rely on academic "professionalism" for the maintenance of academic standards. To an extent this is ensured in the United Kingdom by the system of external assessors and examiners but some doubts have been cast on the comparability of degree standards even within the same subject group (Nevin, 1972).

A more sophisticated measure of output is the "value added" to the students between entry to and exit from the institution. This concept presents problems of definition and is less susceptible to quantification. If it is interpreted as being concerned primarily with knowledge and skills acquisition rather than experiential, attitudinal, cultural and social gains plus personal consumption, then it overlaps with the pass rate criteria and the latter may serve as a proxy. However, to accurately measure and compare this "learning gain" standardised pre-course and post-course tests covering common syllabi would be required

(Attiyeh and Lumsden, 1971 and 1972). This solution was not used in this case.

Enrolments, pass and attrition rates and information on graduate employment by course are all indicators of society's response to the institution's provision of learning opportunities, i.e. they are outcome measures. Now to the question of efficiency. Usually the input-output relationship is summarised in the form of a unit cost but in the United Kingdom the popular approximation is the student staff ratio. This ratio is a function of a number of variables (Delany, 1971; Legg, 1971; Bottomley et al, 1972; Simpson et al, 1972) and an examination of resource utilisation at the institutional level should take account of them. Depending on the complexity of the curriculum this may involve a detailed timetable analysis such as is outlined below.

Consider a college with two departments X and Y with two courses A and B (Figure 1); course A is administered by Department X and course B by Department Y. There are 30 enrolments to course A and 20 to course B. Courses receive and departments provide tuition. Department X provides tuition in subject elements L, M and N whilst Department Y offers subjects O and P. Following a course involves the student reading a number of subject elements and attending a set of meetings with teachers. These meetings (class hours) may be compulsory or optional, involve just one course or be joint with other courses. For example, students enrolled on course A study subject elements L, M, N and O; subjects L and N are compulsory whilst M and O are optional. L involves just course A whereas M, N and O are "joint meetings" involving both courses A and B.

Therefore, to analyse a set of meetings the following information is required:

- for a year of a course ("course year")
  total enrolment = E
- for a particular subset of meetings for a subject element
  enrolment from a particular "course year" = S
  enrolment from all "course years" of all courses = E *
  number of groups formed each assigned to one teacher = g
  hours per annum attended by the student = h

and the department providing the tuition and the type of space used.

Figure 1

Timetable Parameters

		Department		X			Y
		Subject Elements	L	M	N	O	P
	$\boxed{g}$	No. of Groups Formed	2	1	1	1	2
	$\boxed{h}$	Students' Contact Hours	20	15	30	20	20
Course	$\boxed{E}$	Enrolment $\boxed{S}$ = Enrolments to Subject Elements					
A		30	30	20	30	5	
B		20		5	20	20	20
	$\boxed{E*}$	Enrolment from all courses	30	25	50	25	20

From this data the meetings provided by each department can be identified and distributed to those courses receiving tuition in the proportion:

$$\frac{\text{Students enrolled from this course year}}{\text{Students enrolled from all course years}} = \frac{S}{E*}$$

The analysis of the meetings provided by Department X and the logic of the subsequent cost allocation is set out in Figure 2.

As a byproduct a number of "values" of significance in the internal management of resources may be derived (Figure 3). These provide inter alia details of teaching loads, students' tuition loads, class sizes - both those typically received by the students and those provided by the institution - and data on the frequency of demand for teaching space of various types and capacities.

THE CASE RESULTS

Figure 4 summarises the course-year parameters for the response dimension. At this level of aggregation the pattern of pass and attrition rates were remarkably similar overall and by discipline area across the two institutions. The significant differences in response in 1972/73 lay in enrolments per course (higher at Lanchester except in engineering), the percentage without A-level (higher at Lanchester except in social science), and average A-level scores (overall just below 3 = Grade 'C' at Loughborough and just above 2 = Grade 'D' at Lanchester) and the coefficient of variation of A-level (higher at Lanchester). Thus it would appear that in 1972/73 the normal pre-entry to institution quality as measured by A-level scores was consistently higher and less variable at Loughborough. Subsequently, however, mean internal examination scores were lower and more variable at Loughborough although not significantly so.

As suggested above, one indicator of society's response to the final outputs of an institution is the initial employment of graduates and their starting salaries. In 1972/73 this information was only available for 20% of the graduates at Lanchester and 50% of the graduates at Loughborough. From this sample it seemed that discipline area rather than institution was the more important determinant of initial salary and the correlation between starting salary and examination mark although positive in the majority of cases was by no means strong.

The pattern of resource utilisation (Figure 5) is quite different across the two institutions. Lower tuition loads (except social science), larger classes, a higher incidence of tuition from "service" departments (except science) and much larger "savings" in tuition demands through joint meetings were consistently observed at Loughborough. Of these differences the most striking was the incidence of classes involving more than one course which was far higher in all disciplines at Loughborough. Typically, the Lanchester undergraduate found himself in classes comprised almost entirely (97%) of students from his own courses whereas the Loughborough student experienced classes in which 40% of the students were from courses other than his own. The sizes of seminars and tutorials are constrained by what the academics consider to be effective learning/teaching situations and joint meetings will not alter these constraints. However, lecturing to one hundred is often as effective as lecturing to ten and it is in this - the lecture content of the curriculum - that joint meetings have their economic impact. As a consequence of larger classes and joint meetings undergraduate unit

Figure 2

The Logic of a Department Cost Allocation on a Meetings Basis

Department			X	
Subject Elements		L	M	N
Groups formed	g	2	1	1
Students' Contact Hours	h	20	15	30

Course	Enrolment E	Enrolment to Subject Elements S		
A	30	30	20	30
B	20		5	20

	L	M	N	
E* Enrolment from all Courses	30	25	50	
Meetings provided (g) (h)	40	15	30	→ Total = 85
Meetings received (g) (h) (S/E*)				
Course A	40	12	18	→ Total = 70
Course B		3	12	→ Total = 15

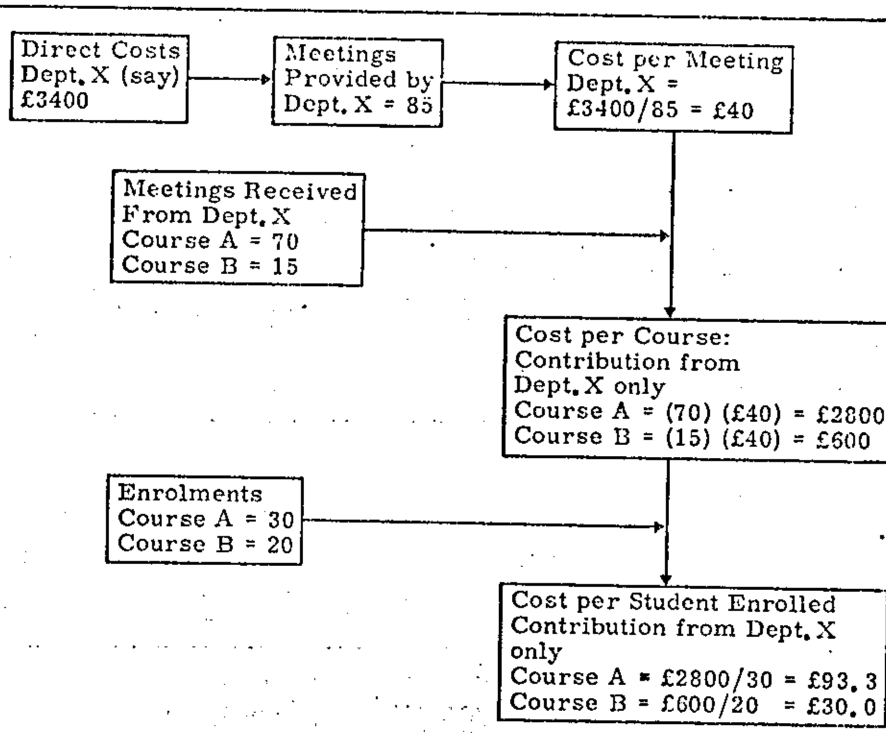

Figure 3

Timetable Parameters

Consider the jth year of a course i ["course-year" (i, j)] which attends a set of meetings k in a subject element as part of its timetable. Then:

Enrolment to course-year (i, j) is E_{ij}

Enrolment from course-year (i, j) to this set of meetings k is S_{ijk}

Total enrolment from all course-years to this set of meetings k is E^*_k

$$= \sum_i \sum_j S_{ijk}$$

If this set of meetings is split up into groups, the number of groups each assigned to <u>one</u> teacher is g_k

and

The hours per annum attended by a student involved in this set of meetings is h_k

Thus, <u>for a course-year (i, j)</u>

1 STUDENTS' TUITION LOAD = Hours of timetabled contact with faculty that the student on average received $= \sum_k \left[(h_k)\ (S_{ijk})\right] / E_{ij}$

2 CLASS HOURS timetabled for a course $= \sum_k \left[(h_k)\ (g_k)\right] = \alpha$

3 Summed over a department or discipline area or for the institution the statistic "Meetings" counts joint meetings (i.e. meetings involving two or more courses) several times. Therefore, when several courses attend the same subset of meetings the timetabled hours may be allocated pro rata to the number of students attending from a course, i.e.

ALLOCATED CLASS HOURS $= \sum_k \left[(h_k)\ (g_k)\ (S_{ijk}/E^*_k)\right] = \beta$

4 Hence CLASS HOURS "SAVED" $= \alpha - \beta$

5 STUDENTS' AVERAGE GROUP SIZE = Average Class Size that the student typically experienced

$$\frac{\sum_k \left[E^*_k/g_k\right]\left[\frac{(h_k)\ (S_{ijk})}{E_{ij}}\right]}{\sum_k \left[\frac{(h_k)\ (S_{ijk})}{E_{ij}}\right]}$$

INSTITUTION'S AVERAGE GROUP SIZE = Average Class Size provided by the Institution

$$\frac{\sum_i \sum_j \sum_k \left[E^*_k/g_k\right]\left[(h_k)\ (g_k)\ (S_{ijk}/E^*_k)\right]}{\sum_i \sum_j \sum_k \left[(h_k)\ (g_k)\ (S_{ijk}/E^*_k)\right]}$$

Figure 4

Summary of Average "Course-Year" Response Parameters 1972/73 (1)

	All Disciplines			Engineering		Science		Social Science	
	Both	LAN.*	LOU.**	LAN.*	LOU.**	LAN.*	LOU.**	LAN.*	LOU.**
Number of "Course Years"	226	88	138						
RESPONSE									
Enrolment	20	25	17	18	21	19	14	43	12
A-Level Score (2)	2.51	2.06	2.80	1.91	2.87	1.82	2.79	2.38	2.64
Coefficient of Variation of A-Level	0.27	0.33	0.22	0.37	0.23	0.35	0.24	0.28	0.18
Percentage without A-Level	20	27	15	42	22	25	5	12	16
Entry Mark	54.6	55.9	53.8	57.2	54.6	55.4	53.0	54.3	53.2
Coefficient of Variation of Entry Mark	0.13	0.11	0.15	0.11	0.15	0.12	0.16	0.10	0.12
Exit Mark	54.8	56.2	54.0	58.4	54.6	55.8	52.9	53.2	54.2
Coefficient of Variation of Exit Mark	0.15	0.14	0.16	0.14	0.17	0.16	0.18	0.13	0.12
Pass Percentage	87	86	88	85	87	85	87	90	89
Fail Percentage	10	11	9	14	10	12	9	8	6
Drop Out Percentage	3	3	3	1	2	3	4	2	5

Notes:

1. The normal duration of undergraduate programmes in the United Kingdom is three "course-years".
2. A-Level is the normal qualification for undergraduate programmes. The A-level scores were calculated as follows: 'A' = 5; 'B' = 4; 'C' = 3; 'D' = 2; 'E' = 1.

* LAN.: Lanchester ** LOU.: Loughborough

Figure 5

Summary of Average "Course-Year" Resource Utilisation Parameters 1972/73

	All Disciplines			Engineering		Science		Social Science	
	Both	LAN.*	LOU.**	LAN.*	LOU.**	LAN.*	LOU.**	LAN.*	LOU.**
Number of "Course Years"	226	88	138						
RESOURCE UTILISATION									
Students' Tuition Load (Hours)	584	668	529	773	561	764	561	425	448
Students' Class Size	33	18	43	13	49	12	37	30	41
Standard Deviation of Students' Class Size	24	9	34	6	41	5	29	24	28
Percentage of Class Hours Provided by "Service" Departments	31	28	32	24	30	36	21	29	46
Percentage of Class Hours "Saved"	37	3	59	0	57	0	59	9	71
Cost per student enrolled £ (1)	635	940	441	1126	412	1150	486	445	399

Note:

1. The costs allocated include the salaries, superannuation and national insurance of academic, technician and administrative staff deployed at the level of departments together with recurrent expenditure on teaching materials, the maintenance and hire of teaching equipment, and the cost of short courses and field work. The costs of the full-time staff were established by reference to salary scale mid-points in 1972/73; the costs for part-time staff were "actual" in 1972/73.

* LAN.: Lanchester ** LOU.: Loughborough

costs per annum although reasonably close in social science were in engineering and science and overall significantly lower at Loughborough.

CONCLUSIONS

In the present climate of concern with the proportion of GNP allocated to higher education and in the absence of an accurate specification of cause and effect in education attention inevitably focuses on cost effectiveness. At a discipline level of aggregation the Lanchester-Loughborough case apparently provides the sort of intelligence which central budget allocators seek, i.e. few significant differences in "response" but quite different patterns of instruction leading to very different unit costs. There were examples in both institutions of courses with response and resource utilisation patterns significantly different from the norms for their institution and discipline. The monitoring of these divergencies would have prompted discerning questions the answers to which might have helped the decision takers to isolate and to support the genuine cases of development and diversity. It is to be hoped that whatever "standardising tendencies" emerge through the increasing role of central planning authorities and agencies (Trow, 1974) there will remain scope for the exercise of subjective judgments at the sharp end. However the case for internal resource allocation based in part on past effectiveness and efficiency is not without support.

Further research is required firstly, to replicate the Lanchester-Loughborough study in a variety of settings selected for their diversity and supposed similarity; and secondly to develop accurate and reliable measures of outcome initially of learning gain and ultimately of the value-added type. This second task is formidable and the probability is that it will require efforts on the part of many investigators and will proceed only slowly. Meanwhile the system will rely on existing examining arrangements and on the comparability of academic standards within and across institutions. In these circumstances improvements in cost effectiveness may prove to be misleading: more students may pass through the system at the same or with a less than proportional increase in costs but the value added to the additional students may be outweighed by the decline in value added to the existing students. Nevertheless, a move towards the systematic collection and analysis of data on institutional outcomes and resource utilisation is overdue. Regular reports at the course level would facilitate internal "management by exception" and establish a data base and prompt the research from which a greater understanding of the teaching/learning process might be achieved.

ACKNOWLEDGEMENTS

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TRACING THE "EFFICIENT" FRONTIER IN BRITISH UNIVERSITIES

'A Discussion Paper'

Abstract

Using published data on five outputs (or output proxies) and five inputs (or input proxies) a linear programming approach is explained and used to trace the "efficient" frontier in 49 UK universities/university colleges for the academic years 1972/73 and 1973/74. This constitutes a tentative first step in the development of an overall ranking criterion for multi-objective institutions. The paper ends with an outline of possible future directions for research in this area.

Introduction

Most educational systems have a number of objectives which not infrequently are inconsistent. Universal agreement among educators is confined to large generalisations which tend to establish the boundaries of social policy rather than give content to realisable goals - "to preserve and enhance the intellectual stock", "to facilitate equal opportunity", and so on. It is difficult to disagree with any common understanding of such bromides and equally difficult to deploy them usefully in a management context. The more detailed the list of goals the more likely it is to be disputed in terms of inclusions, omissions, and interpretations. However, there seems to be broad agreement on the major output programmes for higher education - instruction (or the transmission of knowledge).... and research (or the acquisition of knowledge).

The measurement of research output is immensely difficult. Various processes have been suggested - a weighted sum of the publications produced, the level of research funds attracted or the quality weighted hours spent on personal research (Cartter (1965), Layard and Verry (1973)). In this paper expenditures from research grants is the chosen proxy. Of course, this is essentially an input measure and its use can only be justified as an attempt to obtain a more realistic mapping of the teaching outcomes.

There are at least two schools of thought on how to conceptualise the outcomes of the teaching function:- firstly, the changes in students' characteristics associated with various institutional input and process variables; and secondly, the characteristics of the learning opportunities made available. The changes wrought in students' skills, knowledge, attitudes and values between entry to, and exit from, university reflect *their* learning functions and are only indirectly related to the institution's production function. The outcomes attributable to the institution (and the institution alone) are the magnitude and quality of the services made available. Below it is assumed that student enrolments on undergraduate and postgraduate programmes are an adequate proxy for the magnitude of teaching services made available. This assumes that the 'quality' of the places provided on an organised curriculum both within and across institutions is comparable.

Concepts of Efficiency

The theory of the firm in neoclassical economics assumes the existence of a production function which defines the relationship between inputs and outputs. Consider an industry where two factors of production are employed to produce a single output under conditions of constant returns to scale. Firms operating in this industry can be plotted on a graph (*Figure 1*) against their unit-output values.

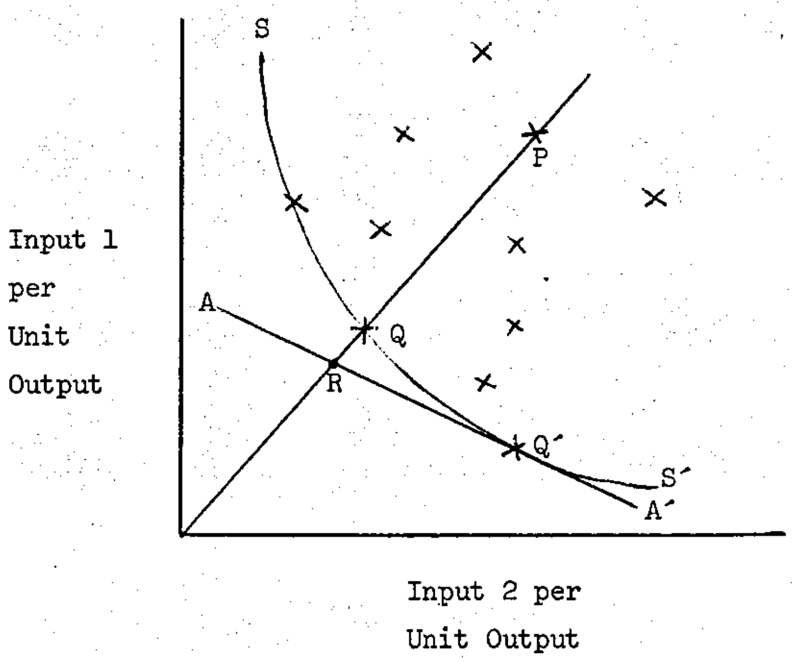

Figure 1

Farrell (1957) has used this diagram to measure and distinguish between a firm's *technical* efficiency and its *price* efficiency. SS´ is the envelope of the observations for all firms. No firm is able to produce a unit of output with an input ratio to the South-West of SS´, ie: SS´ represents the production frontier. Consider firm P. Point Q represents a (perhaps hypothetical) firm which is more efficient than P although using the same ratio of inputs. If the straight line AA´ tangential to SS´ at Q´ is the iso-cost line based on the input-price ratio then firm Q´ is less costly than Q and, therefore, point R represents a less costly situation than Q (and hence of P) but with the same input ratio. Therefore:

$\frac{OQ}{OP}$ represents the technical efficiency of P;

$\frac{OR}{OQ}$ represents the price efficiency of Q; and

$\frac{OR}{OP}$ represents the overall efficiency of P. (*Note 1*)

In the rest of this paper we are concerned solely with "technical efficiency". Indeed, if we compare two or more firms with the same input mix they have the same "price efficiency".

Estimating the Production Frontier From Observed Data

We can estimate the production frontier as a series of line segments from observed data if we assume that the frontier is

a) convex (ie: if two points are attainable in practice a point representing a weighted average of the two is also obtainable in practice), and

b) nowhere has a positive slope (ie: extra inputs always produce extra outputs however small).

One way to ensure that the production frontier nowhere has a positive slope is to add points at infinity $(0, \infty)$, $(\infty, 0)$. The establishment of a line segment parallel to the axes can also be achieved using $(\max_1 \min_2)$ $(\min_1 \max_2)$ with easier computation.

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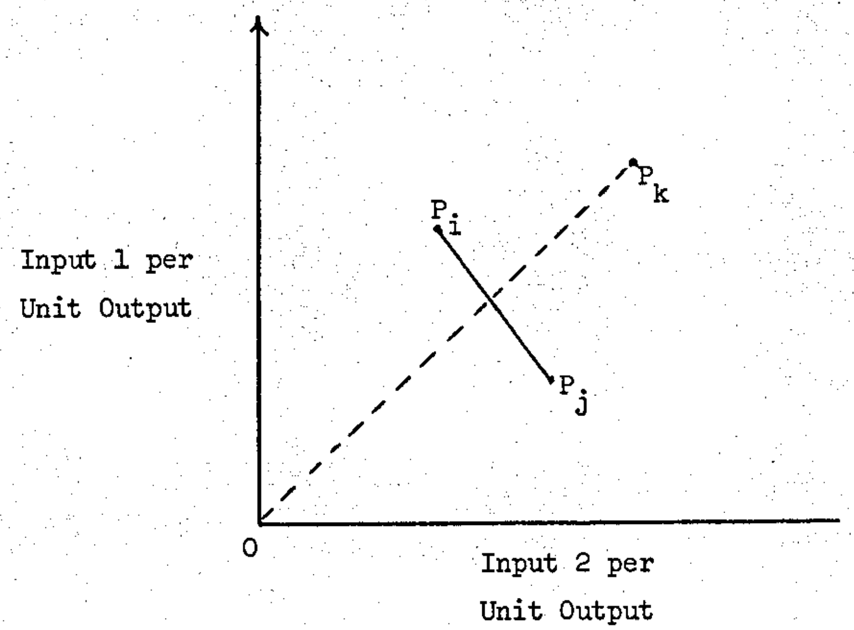

Figure 2

Consider points P_i and P_j which are adjacent frontier points, and point P_k the firm under examination (*Figure 2*). The co-ordinates of P_i, P_j and P_k are $\underline{P}_i$, $\underline{P}_j$ and $\underline{P}_k$.

Let λ_{ijk}, μ_{ijk} be the solutions of:

$$\lambda\underline{P}_i + \mu\underline{P}_j = \underline{P}_k$$

Any point P_l on the line through P_i and P_j has $\lambda_{ijl} + \mu_{ijl} = 1$. For any point P_m for which OP_m cuts P_i, P_j internally λ_{ijm} and μ_{ijm} are both positive. Hence if P_i, P_j lies between P_k and the origin, $\lambda_{ijk} + \mu_{ijk} \geqslant 1$ and λ_{ijk} and μ_{ijk} are both positive. Therefore, the line joining P_i, P_j is part of the frontier if, and only if, $\lambda_{ijk} + \mu_{ijk} \geqslant 1$ for all points in the set. Thus we can establish the production frontier as a set of linked points and the technical efficiency of any P_k is equal to the maximum of $1(\lambda_{ijk} + \mu_{ijk})$ for all frontier segments P_i, P_j. Since the frontier is assumed to be convex this maximum will be attained when λ_{ijk} and μ_{ijk} are both positive. So we can compare a P_k with that point where OP_k cuts the frontier which although hypothetical is theoretically obtainable since it is a weighted average of two frontier firms. It will have the same input ratio as P_k but will be using fewer inputs to produce unit output. *(Note 2)*

If we generalise to n inputs and m outputs but retain the assumption of constant returns each firm now has an input vector $\underline{X}$, and an output vector $\underline{Y}$, and can be represented as a point in m + n dimensional space (ie: $\underline{P}_i = (\underline{X}_i', \underline{Y}_i')$). The set of points is extended to include points at infinity as before. Since there are constant returns if $\underline{P}_i = (\underline{X}_i, \underline{Y}_i)$ is efficient then $(\frac{1}{2}\underline{X}_i, \frac{1}{2}\underline{Y}_i)$ must be efficient also and hence the origin must be added to the set as a frontier point. Instead of lines and line segments we now have hyperplanes and *facets*. A facet is the part of the hyperplane whose whose points can be represented as weighted averages with non-negative weights (except for the origin) of the m + n defining points. The frontier is now a surface in m + n dimensional space made up entirely of such facets.

To compare a point P_k with a hypothetical point on the boundary we need to compare P_k with a linear combination of $(m + n)$ frontier points including the origin. Farrell suggests matching the inputs of P_k and exceeding the outputs of P_k by the same ratio for each output. This ratio represents the technical efficiency.

Thus, we have that if $\underline{\delta}$ is the solution of:

$$(\underline{Y}_i, \underline{Y}_{i+1}, \ldots \underline{Y}_{i+m+n-2}, \underline{0})\, \underline{\delta} = (\sum_1 \delta_j)\, \underline{Y}_k$$

$$(\underline{X}_i, \underline{X}_{i+1}, \ldots \underline{X}_{i+m+n-2}, \underline{0})\, \underline{\delta} = \underline{X}_k$$

then the facet defined by $\underline{P}_i \ldots \underline{P}_{i+m+n-2}$, $\underline{0}$ is part of the frontier if, and only if, $\sum \delta_1 \geqslant 1$ for all $\underline{P}_k$ in the set. The technical efficiency of $\underline{P}_k$ is (as before) the maximum of $1/\sum \delta_j$. Therefore an efficient firm can produce $\underline{Y}_k$ outputs from $1/\sum \delta_j \underline{X}_k$ inputs (ie: less inputs than $\underline{P}_k$) and, given constant returns to scale, $\sum \delta_j \underline{Y}_k$ outputs from $\underline{X}_k$ inputs (ie: more outputs than $\underline{P}_k$).

A Linear Programming Approach

There are several methods available for identifying frontier observations but the most general and least sensitive to prior specification of the form of the production function is the linear programming techniques. The LP approach was originally suggested by Farrell (1957, *op.cit.*) and later deployed in the measurement of educational production by Carlson (1972, 1975) and Levin (1974). Briefly, the approach requires the identification of the input and output variables of all the institutions in the population where all the institutions are judged to have comparable quality outcomes (or where one or more measures of quality are explicitly included as characteristic variables). LP is then used to maximise one output, subject to satisfying other output and input constraints. The result of this is a production efficiency index that will be 1.0 for all institutions on the frontier and less than 1.0 for all other institutions for that output.

Consider the boundary and a point P_k. If P_k is not on the boundary we can move from P_k in the direction of increasing output 1 or output 2 until we reach a boundary point which will be a linear combination of the frontier points (*Figures 3 and 4*).

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Figure 3

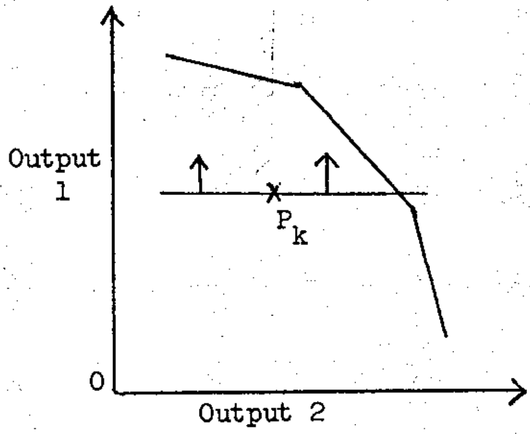
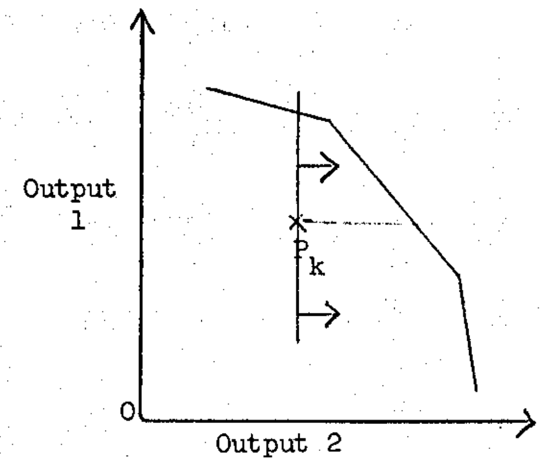


Figure 4



Thus, if we select a point in the set and one of the outputs we can find the boundary in one direction and at the same time identify some of the frontier points. To accomplish this for institution S and output r we formulate a linear programming problem as follows:

If X_{it} = the quantity of the ith resource used by institution t,
and Y_{jt} = the quantity of the jth output produced by institution t, then the point on the frontier in the direction (starting from institution s) of increasing output r is given by $z_1, \ldots\ldots, z_t$ where we:

$$\max \sum_{t=1}^{T} z_t Y_{rt} \quad ,$$

$$\text{subject to } \sum_{t=1}^{T} z_t X_{it} \leqslant X_{is} \quad i = 1, \ldots\ldots N$$

$$\sum_{t=1}^{T} z_t Y_{jt} \geqslant Y_{js} \quad j = 1, \ldots. r-1, r+1, \ldots. m$$

$$z_t \geqslant 0 \quad t = 1, \ldots.. T$$

The optimal solution to this linear program will identify some of the frontier points, ie: the points with non-zero weights. Hence we can identify all the frontier institutions if we solve the linear program for every institution S for each of the outputs r. For any one output we can measure how near an institution is to the frontier by the ratio of its output to the value of the objective function at optimal, ie: "efficiency" in *one* direction (rth output) is given by $Y_{rs}/\sum z_t Y_{rt}$. This approach assumes a consistent slope of the frontier (either positive or negative) but does not insist on constant returns to scale (ie: does not include the origin in the set of points).

Frontier Universities in the UK 1972/73 and 1973/74

Information on the following variables for the academic years 1972/73 and 1973/74 was collected from DES published statistics for all the UK universities except the London Graduate School of Business, the Manchester Business School, the Welsh National School of Medicine and St. David's Lampeter:

Outputs 1 Undergraduate enrolment - full-time;

2 Undergraduate enrolment - full-time plus part-time;

3 Postgraduate enrolment - full-time;

4 Postgraduate enrolment - full-time plus part-time; and

5 Expenditure from research grants (a proxy for research involvement).

Inputs i Total full-time teaching and research staff paid directly from university funds;

ii Salaries of teaching and research staff;

iii Other departmental salaries and wages;

iv Departmental and laboratory expenditure; and

v Total expenditure.

The institutions identified as being on the frontier are listed in *Table 1*. The complete results of the analysis (ie: "efficiency" index equals 1.0 for frontier institutions and less than 1.0 for other institutions) for each of the outputs 1 to 5 is provided in *Appendices A and B*. By definition, if an institution is on the boundary in one direction it is on the boundary. The index produced is a measure of "efficiency" on that output programme given the need to satisfy all other output and input constraints.

Out of the total sample of 49 institutions 24 are identified as "efficient" in one or the other or both of the academic years examined. Sixteen universities/university colleges appear as boundary institutions in both years. The eight institutions listed as on the boundary in only one of the two years, achieve at least one high index on the five output programmes examined in the year in which they are not on the boundary. Hence, the "efficiency" ranking appears to be reasonably stable over time. (See *Table 2*).

Table 1

Frontier Universities 1972/73 and 1973/74

1972/73	1973/74
Bath	–
–	Birmingham
Cambridge	Cambridge
Essex	Essex
Exeter	Exeter
–	Keele
Kent	Kent
Lancaster	Lancaster
Leeds	–
–	Leicester
London	London
UMIST	–
Oxford	Oxford
Sussex	Sussex
Warwick	Warwick
York	York
Bangor	Bangor
Aberystwyth	Aberystwyth
Cardiff	Cardiff
Swansea	Swansea
Heriot Watt	Heriot Watt
St. Andrews	St. Andrews
Stirling	–
Queens (Belfast)	–

Boundary Institutions:	21	19
Total Sample:	49	

Table 2

Ranking on Maximum Score of Non-Boundary Institutions

	1972/73	1973/74
Aston	12=	15=
Bath	-	1=
Birmingham	2=	-
Bradford	19	20=
Bristol	21=	24=
Brunel	7=	4=
City	27=	30
Durham	5	10
East Anglia	2=	6=
Hull	7=	15=
Keele	10	-
Leeds	-	4=
Leicester	1	-
Liverpool	20	28=
Loughborough	6	11
Manchester	27=	22=
UMIST	-	17=
Newcastle upon Tyne	23=	20=
Nottingham	4	9
Reading	9	12=
Salford	21=	24=
Sheffield	25	26=
Southampton	15=	12=
Surrey	17=	19
UWIST	15=	8
Aberdeen	17=	28=
Dundee	26	26=
Edinburgh	12=	1=
Glasgow	23=	22=
Stirling	-	6=
Strathclyde	12=	12=
Queens (Belfast)	-	1=
Ulster	11	17=

An examination of the equality constraints in the optimum solutions revealed "staff numbers" and "recurrent departmental and laboratory expenditure" as the critical constraining variables. It is on these variables that the majority of non-boundary institutions would have to operate if they wished to move towards the frontier. (*Note 3*)

What Next?

So far we have tested out one "machine". Using five inputs and five outputs for 49 institutions the boundary institutions have been identified. Next ratios of actual output to boundary point output have been calculated and used to rank the non-frontier institutions on each of the five output programmes. (It would also be possible to rank the non-frontier institutions on their use of inputs.)

The next stage would be to formulate the problem according to Farrell (1957, *op.cit.*) as a linear programming problem by not assuming constant returns to scale and thereby rank the non-frontier institutions according to his concept of *overall* technical efficiency. (*Note 4*)

A further stage would be to estimate a production function by multi-regression analysis using the boundary institutions only following Truehart and Weathersby (1977). This would describe the resource use characteristics of relatively efficient institutions and might lead to answers on a number of important questions such as:

How much could an average institution save (or have available for alternative use) by altering its resource use patterns to match those of relatively efficient institutions?

Are there economics of scale?

Among relatively efficient institutions, what mix of imputs is technically optimal?

Alongside these developments we could improve the data base by collecting more recent data and polytechnic data and by including quality dimensions (such as wastage rates) and by improving the measurement of research outcomes. We might also partition the sample to test for the effects of discipline mix or stage of development (redbrick, new, ex-CATS, for example).

The same models might also be deployed on within-institution data. (The Lanchester/Loughborough data although now outdated would provide a useful test base). This particular line of development would be in line with the broad ovjectives of the Institutional Management of Higher Education Programme of OECD.

In sum, there are a number of avenues for "search". Whichever line of development is followed, it will be relatively expensive in computer time and, in the case of within-institution analysis, we suspect it might also be expensive in data collection. Nevertheless, we believe that this area of research is potentially rich in increasing our understanding of resource use patterns in higher education and in improving our planning and control at both the macro and micro level.

J. R. CALVERT

D. W. BIRCH

LOUGHBOROUGH, JANUARY 1978

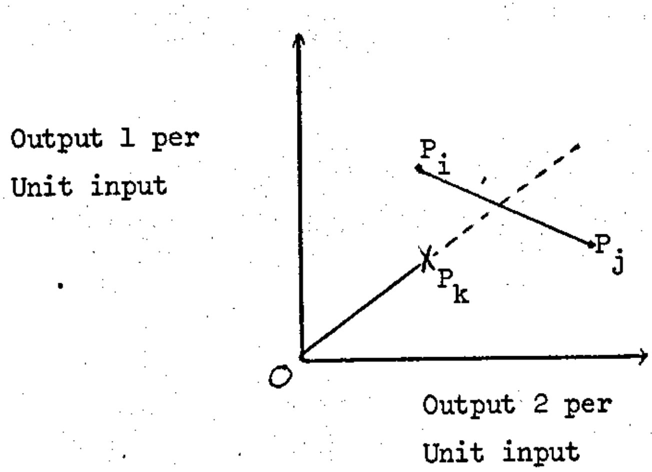
NOTES

Note 1

There is one other concept of efficiency from the neoclassical theory of the firm - "preference efficiency" - which describes the utility maximising mix of multiple outputs. Leibenstein (1976) suggests a fourth type of efficiency - "X-efficiency" - which describes managerial ability and willingness to enable organisations to accomplish their objectives.

Note 2

We can adapt the same approach to two outputs and one input. The assumptions now are that the production frontier is concave to the origin and nowhere has a positive slope. So to close the boundary we need to extend the set to include $(\max_1, 0)(0, \max_2)$ or simply $(\max_1 \min_2)(\min_1 \max_2)$ as before.



Let λ^*_{ijk}, μ^*_{ijk} be the solutions of $\underline{\lambda}^*_{ijk} \underline{P}_i + \underline{\mu}^*_{ijk} \underline{P}_j = P_k$. Any point on the line through P_i and P_j has $\lambda^*_{ijk} + \mu^*_{ijk} = 1$. Hence if P_k lies between the origin and the segment $P_i P_j$, $\lambda^*_{ijk} + \mu^*_{ijk} \leqslant 1$ and if OP_k cuts $P_i P_j$ internally λ^*_{ijk}, μ^*_{ijk} are both $\geqslant 0$. Therefore the line joining P_i and P_j is part of the frontier if, and only if, $\lambda^*_{ijk} + \mu^*_{ijk} \leqslant 1$ for all P_k in the set and the technical efficiency of P_k is the maximum of $\lambda^*_{ijk} + \mu^*_{ijk}$ for all segments of the boundary. The concavity of the boundary ensures that at the maximum λ^*_{ijk} and μ^*_{ijk} are both positive.

Note 3

In brief the procedure involves:

1. For each university, trying to identify a hypothetical institution which produces equal or more outputs with less than or equal inputs.
2. This hypothetical institution will be a linear combination of several frontier institutions (or a proportion of one frontier institution).
3. In the optimum solution to the LP some constraints will be equalities.
4. It is on these equality constraints that the university under examination would have to operate if it wished to move towards the hypothetical boundary institution since if the <u>in</u>equality constraints are altered the basic solution is unaltered and the index of "efficiency" is unaltered.

Note 4

If we do not assume constant returns to scale we can choose any $m + n$ vectors for a facet and allow only positive weights. If we extend $\underline{\delta}$ to $\underline{z}$ and extend the set of vectors to include *all* the *efficient* ones then we have one equation rather than several - one for each facet. Hence:

$$(\underline{Y}_{1}, \ldots\ldots, \underline{Y}_T)\,\underline{z} = \sum z_j \underline{Y}_k$$

$$(\underline{X}_{1}, \ldots\ldots, \underline{X}_T)\,\underline{z} = \underline{X}_k$$

and if we max $\sum_{1}^{T} z_j$ by LP then answer as a basic solution will have at most $m + n$ variables mentioned, and each z_j will be non-negative.

Therefore, let $Q = \sum z_j$

and max Q where

$$z_1 \underline{Y}_1 + z_2 \underline{Y}_2 + \ldots\ldots\ldots + z_T \underline{Y}_T - Q\,\underline{Y}_k = 0$$

$$z_1 \underline{X}_1 + z_2 \underline{X}_2 + \ldots\ldots\ldots + z_T \underline{X}_T = \underline{X}_k$$

$$z_1 + z_2 + \ldots\ldots\ldots + z_T - Q = 0$$

This needs to be solved for each P_k ie: coefficients of Q change as do the right hand sides

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Appendix A

Efficiency Ratings 1972/73

	Output 1	Output 2	Output 3	Output 4	Output 5
Aston	0.86	0.86	0.81	0.85	0.24
Bath	1.00	1.00	1.00	1.00	1.00
Birmingham	0.80	0.80	0.93	0.97	0.89
Bradford	0.79	0.79	0.60	0.74	0.33
Bristol	0.76	0.75	0.56	0.57	0.53
Brunel	0.91	0.91	0.54	0.94	0.37
Cambridge	1.00	1.00	1.00	1.00	1.00
City	0.66	0.65	0.41	0.65	0.26
Durham	0.94	0.94	0.82	0.89	0.39
East Anglia	0.97	0.97	0.69	0.72	0.55
Essex	1.00	1.00	1.00	1.00	1.00
Exeter	1.00	1.00	1.00	1.00	1.00
Hull	0.91	0.91	0.75	0.78	0.39
Keele	0.89	0.89	0.71	0.88	0.51
Kent	1.00	1.00	1.00	1.00	1.00
Lancaster	1.00	1.00	1.00	1.00	1.00
Leeds	1.00	1.00	1.00	1.00	1.00
Leicester	0.99	0.99	0.95	0.98	0.56
Liverpool	0.78	0.78	0.64	0.69	0.55
London	1.00	1.00	1.00	1.00	1.00
Loughborough	0.92	0.90	0.57	0.72	0.66
Manchester	0.67	0.67	0.68	0.75	0.40
UMIST	1.00	1.00	1.00	1.00	1.00
Newcastle upon Tyne	0.75	0.75	0.58	0.58	0.63
Nottingham	0.93	0.93	0.74	0.95	0.67
Oxford	1.00	1.00	1.00	1.00	1.00
Reading	0.83	0.83	0.86	0.90	0.45
Salford	0.75	0.75	0.52	0.76	0.26
Sheffield	0.74	0.74	0.68	0.70	0.36
Southampton	0.85	0.85	0.83	0.83	0.85
Surrey	0.80	0.79	0.56	0.71	0.38
Sussex	1.00	1.00	1.00	1.00	1.00
Warwick	1.00	1.00	1.00	1.00	1.00
York	1.00	1.00	1.00	1.00	1.00
Aberystwyth	1.00	1.00	1.00	1.00	1.00

Appendix A continued

	Output 1	Output 2	Output 3	Output 4	Output 5
Bangor	1.00	1.00	1.00	1.00	1.00
Cardiff	1.00	1.00	1.00	1.00	1.00
Swansea	1.00	1.00	1.00	1.00	1.00
UWIST	0.83	0.85	0.63	0.63	0.31
Aberdeen	0.80	0.79	0.36	0.37	0.27
Dundee	0.73	0.72	0.48	0.52	0.46
Edinburgh	0.86	0.86	0.59	0.74	0.82
Glasgow	0.74	0.75	0.34	0.47	0.48
Heriot Watt	1.00	1.00	1.00	1.00	1.00
St. Andrews	1.00	1.00	1.00	1.00	1.00
Stirling	1.00	1.00	1.00	1.00	1.00
Strathclyde	0.86	0.86	0.65	0.78	0.56
Queens (Belfast)	1.00	1.00	1.00	1.00	1.00
Ulster	0.85	0.87	0.38	0.37	0.13

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Appendix B

Efficiency Ratings 1973/74

	Output 1	Output 2	Output 3	Output 4	Output 5
Aston	0.86	0.86	0.77	0.82	0.23
Bath	0.96	0.95	0.83	0.91	0.44
Birmingham	1.00	1.00	1.00	1.00	1.00
Bradford	0.78	0.78	0.61	0.74	0.38
Bristol	0.76	0.76	0.55	0.54	0.59
Brunel	0.90	0.90	0.59	0.95	0.40
Cambridge	1.00	1.00	1.00	1.00	1.00
City	0.66	0.66	0.40	0.60	0.28
Durham	0.91	0.91	0.86	0.86	0.42
East Anglia	0.94	0.94	0.74	0.72	0.45
Essex	1.00	1.00	1.00	1.00	1.00
Exeter	1.00	1.00	1.00	1.00	1.00
Hull	0.86	0.86	0.65	0.65	0.25
Keele	1.00	1.00	1.00	1.00	1.00
Kent	1.00	1.00	1.00	1.00	1.00
Lancaster	1.00	1.00	1.00	1.00	1.00
Leeds	0.91	0.91	0.93	0.95	0.43
Leicester	1.00	1.00	1.00	1.00	1.00
Liverpool	0.73	0.73	0.64	0.67	0.49
London	1.00	1.00	1.00	1.00	1.00
Loughborough	0.89	0.89	0.72	0.78	0.61
Manchester	0.74	0.73	0.75	0.77	0.46
UMIST	0.56	0.56	0.83	0.81	0.40
Newcastle upon Tyne	0.76	0.78	0.64	0.62	0.61
Nottingham	0.92	0.92	0.79	0.90	0.64
Oxford	1.00	1.00	1.00	1.00	1.00
Reading	0.85	0.85	0.87	0.88	0.50
Salford	0.76	0.76	0.48	0.66	0.31
Sheffield	0.74	0.74	0.64	0.65	0.42
Southampton	0.87	0.87	0.77	0.76	0.88
Surrey	0.80	0.81	0.60	0.73	0.47
Sussex	1.00	1.00	1.00	1.00	1.00
Warwick	1.00	1.00	1.00	1.00	1.00
York	1.00	1.00	1.00	1.00	1.00
Aberystwyth	1.00	1.00	1.00	1.00	1.00

Appendix B continued

	Output 1	Output 2	Output 3	Output 4	Output 5
Bangor	1.00	1.00	1.00	1.00	1.00
Cardiff	1.00	1.00	1.00	1.00	1.00
Swansea	1.00	1.00	1.00	1.00	1.00
UWIST	0.79	0.81	0.50	0.93	0.35
Aberdeen	0.73	0.73	0.35	0.33	0.24
Dundee	0.74	0.73	0.47	0.49	0.49
Edinburgh	0.96	0.96	0.60	0.78	0.96
Glasgow	0.75	0.77	0.31	0.43	0.57
Heriot Watt	1.00	1.00	1.00	1.00	1.00
St. Andrews	1.00	1.00	1.00	1.00	1.00
Stirling	0.93	0.94	0.45	0.50	0.45
Strathclyde	0.88	0.88	0.72	0.85	0.57
Queens (Belfast)	0.94	0.96	0.68	0.82	0.54
Ulster	0.82	0.83	0.43	0.52	0.16