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## A Software Science Analysis of the Writing of a Technical Paper

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A SOFTWARE SCIENCE ANALYSIS  
OF THE  
WRITING OF A TECHNICAL PAPER

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INTRODUCTION

Several relationships governing the structure and the implementation of computer programs have been found to be essentially independent of the programming languages used [2]. These findings have further been shown to apply to structural properties of published samples of technical prose [4,6], but not yet to the writing or "implementation" of english language text. For a computer program, the relationship between operator and operand usage and the number of elementary mental discriminations used to write it has been found to hold from five minute [1] to ten thousand man-month [5] jobs, but similar experiments with writing times for english text have not been reported. It is the purpose of this paper to present the results of such a study. The experimental procedure will be described in detail, and the method used to obtain the basic parameters will be shown to follow the methods prescribed in chapter 13 of reference [2]. The use of these parameters to obtain estimates of length, potential volume, language level, elementary mental discriminations, and implementation times will be given, but all equations required will be taken directly from reference [2] without derivation (or motivation).

EXPERIMENTAL PROCEDURE

A technical paper [3], intended for a U.S. Army Computer Systems Command Workshop on Software Life Cycle Management was used as the subject to be studied. It was planned and written under quantitatively controlled experimental conditions, from initial outline to final draft. In order to be able to separate the distinct parts of the process, a rigid "Top-Down" approach was followed. The top-down approach was further formalized by introducing a five-tuple requirement. The latter, which appears from software science to be in accord with the "chunking" concept of psychology, required that the initial outline have five headings, and that when it was expanded, any sub-headings introduced would also be in groups of five, producing hierarchies of five-tuples.

With these rigid requirements, it was straightforward to divide the process into the following parts.

1. Title Page
2. Basic Outline (one five-tuple)
3. Expanded Outline (hierarchy of five-tuples)
4. Refined Outline
5. First Draft
6. Draft Abstract

Total times, to the nearest minute or closer, were recorded for each stage of the design and for each hand-written page of the implementation phase. After final completion of the paper, each timed unit of written material was analyzed, using the counting methods of chapter 13 of reference [2]. The detailed counting procedure for each timed unit is shown in Appendix 1. Operators, in addition to punctuation and numbers, include only the list of pronouns, prepositions, conjunctions and auxiliary verbs included in Miller's [7] list of "function words". All other words are operands.

#### OBSERVED DATA

The observed elapsed time in minutes, and the observed counts of unique operators ( $n_1$ ), total operator usage ( $N_1$ ), unique operands ( $n_2$ ) and total operand usage ( $N_2$ ) for each timed unit of each phase can be obtained from Appendix 1. For convenience, they have been collected in Table 1.

Table 1. Observed Basic Parameters

Part	T(Minutes)	$n_1$	$n_2$	$N_1$	$N_2$
1. Title	1	4	5	10	6
2. 5 Point Outline	9.3	25	21	53	28
3. 5x5 Point Outline	11	35	31	96	49
	4.3	12	17	42	22
	6.7	20	19	39	23
	4	26	19	92	31
	2.2	9	8	26	8
4. Final Outline	21	24	53	160	69
	11	24	22	70	29
	21	27	32	47	39
	25	27	42	223	67
	17	20	31	80	52
	13	20	33	52	47
	16	22	36	62	43
	11	23	25	61	28
5. Draft Paper	28	37	43	83	54
	31	23	53	67	65
	10	36	45	79	63
	16	40	47	69	53
	22	44	46	122	72
	11	39	27	120	45
	20	31	49	73	57
	14	28	52	81	55
	21	37	47	84	52
	14	20	33	48	39
	15	29	37	56	43
	15	27	43	62	46
	12	30	30	63	31
	11	37	34	61	37
	17	39	35	91	52
	15	34	45	64	51
	17	31	45	81	58
	10	23	20	44	26
6. Draft Abstract	13	22	31	48	41

THE LENGTH EQUATION

The length of a computer program, defined as  $N = N_1 + N_2$ , can be estimated from

$$\hat{N} = n_1 \log_2 n_1 + n_2 \log_2 n_2$$

According to reference [ 2 ], the same equation should be applicable to english text, provided the values of  $n_1$  and  $n_2$  are corrected for the effect of redundancy in prose. Using the reduction value cited,  $k = 0.4$ , estimated and observed lengths of the 18 pages of part 5 and the single page of part 6 were obtained. The results are given in Table 2.

Table 2. Observed (N) and Calculated ( $\hat{N}$ ) Lengths of Prose Pages. ( $k = 0.4$ )

<u>N</u>	<u><math>\hat{N}</math></u>	<u>N</u>	<u><math>\hat{N}</math></u>	<u>N</u>	<u><math>\hat{N}</math></u>
137	128	136	130	143	115
132	123	136	137	115	126
142	130	87	73	139	120
122	144	99	99	70	53
194	150	108	108	89	73
165	99	94	86		
130	129	98	109		
	SUMS			2336	2132
	MEANS			122.9	112.2
	RELATIVE ERROR $(N-\hat{N})/N$			0.079	$\pm$ 0.138

POTENTIAL VOLUME AND LANGUAGE LEVEL

The potential volume ( $V^*$ ) of a computer program is defined as

$$V^* = (n_1^* + n_2^*) \log_2 (n_1^* + n_2^*)$$

where  $n_2^*$  is the count of conceptually unique input/output operands required by a procedure call upon the program, and  $n_1^* = 2$ . Because an observed value of  $n_2^*$  is not available for english text, the potential volume can not be evaluated directly. Indirectly, however, it can be obtained from the relation

$$V^* = LV$$

where

$$L \approx 2 \eta_2 / \eta_1 N_2$$

and

$$V = (N_1 + N_2) \log_2 (\eta_1 + \eta_2)$$

The potential volume can thus be estimated from the data in Table 1, and having  $V^*$ , one may solve iteratively for  $\eta_2^*$ . The language level ( $\lambda$ ) defined as

$$\lambda = LV^*$$

May then be obtained from the data of Table 1 also. Table 3 shows the results, divided between outlines and prose.

For the outline material, the language level has a mean of  $3.54 \pm 2.21$  if the title page is included, or  $3.16 \pm 1.73$  if it is not. For the prose pages, the value  $\bar{\lambda} = 2.17 \pm 0.95$  is in good agreement the value listed for english, 2.16 with a variance of 0.74, in Table 9.4 of reference [2]. The intuitive view that an outline should be at a higher level than an equivalent page of prose also appears to be confirmed.

#### CALCULATING DESIGN AND WRITING TIMES

According to reference [2], the programming time can be calculated from

$$\hat{T} = (V^*)^3 / (\lambda^2 S)$$

where the Stroud Number  $S$  is taken as 18 elementary mental discriminations per second, or 1080 per minute.

Using the values of  $V^*$  and  $\lambda$  given in Table 3, and summing the individual items in each part gives the values of observed and calculated times shown in Table 4.

Table 3. Input/Output Operand Counts ( $n_2^*$ ), Potential Volumes ( $V^*$ ) and Language Levels ( $\lambda$ ) of Outlines and Prose Pages.

Outlines				Prose			
Part	$n_2^*$	$V^*$	$\lambda$	Part	$n_2^*$	$V^*$	$\lambda$
1	5	21	8.81	5	9	37	1.60
2	7	27	1.61		13	58	4.15
3	8	32	1.15		9	36	1.42
	9	40	5.16		9	39	1.55
	7	27	2.24		9	37	1.06
	8	32	1.50		8	31	.94
	8	31	6.86		11	46	2.53
4	19	92	5.88		13	58	3.92
	8	35	2.19		10	42	2.08
	8	31	1.87		10	42	3.57
	17	82	3.82		9	36	2.11
	10	45	2.66		11	46	3.17
	9	40	2.80		9	36	2.31
	11	47	3.56		7	30	1.49
	9	39	3.00		8	31	1.06
					9	38	1.95
					10	43	2.18
					6	25	1.70
				6	8	35	2.41
Mean Levels			3.54 $\pm$ 2.21				2.17 $\pm$ .95



Table 4. Observed (T) and Calculated ( $\hat{T}$ ) Design and Writing Times for one Technical Paper.

Part	T	$\hat{T}$
1. Title	1	0.1
2. Five Point Outline	9.3	7.0
3. 5x5 Point Outline	28.2	42.9
4. Final Outline	135	105.2
5. Draft Paper	299	289.6
6. Draft Abstract	13	6.8
Total Time (Minutes)	485.5	451.6
Total Time (Hours)	8.09	7.53
Difference (Minutes)		33.9
Difference (Percent)		7.0
Coefficient of Correlation		0.993
Variance		0.987
Line of Regression:	$T = 2.4 + 1.043 \hat{T}$	

### CONCLUSIONS

For one experimental case, in which the design or outlining phase took some 36% of the total time to produce a technical paper, both designing and writing times were in reasonable agreement with the hypothesis of software science. This result, if found to be reproducible in other laboratories, would tend to confirm the basic nature of the relationships involved.

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- [2] Halstead, M.H. Elements of Software Science. Elsevier North-Holland, Publisher, New York, 1977.
- [3] Halstead, M.H. Potential Impacts of Software Science on Software Life Cycle Management. Purdue Computer Science Dept. TR 237, July 1977.
- [4] Halstead, M.H. A Quantitative Connection Between Computer Programs and Technical Prose. Digest of Papers, IEEE COMPCON, Fall, 1977.
- [5] Halstead, M.H. Interpretation of the Walston-Felix Productivity Data, in Forum Section of IBM Systems Journal, Vol 16, No. 3, 1977.
- [6] Kulm, Gerald. Language Level Applied to the Information Content of Technical Prose. In Collective Phenomena and The Applications of Physics to Other Fields of Science. N.A. Chigier and E.A. Stern, eds. Fayetteville, N.Y. Brain Research Publications, 1975, pp. 401-408.
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## APPENDIX 1

Page 0 Title Page (First Version)

Time July 12, 1977 9:40 - 9:41 T = 1 min

<u>Operators</u>			<u>Operands</u>		
1.	u.c.	7	1.	future	1
2.	$\mathcal{P}$	1	2.	research	1
3.	in	1	3.	role	1
4.	the	$\frac{1}{10}$	4.	science	1
			5.	software	$\frac{1}{6}$

Note: u.c. means upper case or capitalization.

$\mathcal{P}$  means new paragraph or indentation.

$$n_1 = 4, \quad n_2 = 5, \quad N_1 = 10, \quad N_2 = 6$$

Time July 12, 1977 09:41 - 09:50:20 T = 9.3 min

1.	I	1	1.	accomplishments	1
2.	2	1	2.	appears	1
3.	3	1	3.	areas	1
4.	4	1	4.	based	1
5.	5	1	5.	better	1
6.	u.c.	18	6.	branch	2
7.	)	5	7.	complete	1
8.	.	3	8.	engineering	3
9.	;	1	9.	future	1
10.	-	1	10.	leading	1
11.	A	2	11.	natural	1
12.	be	1	12.	needs	1
13.	in	1	13.	nominee	1
14.	is	2	14.	outlined	1
15.	of	3	15.	present	1
16.	and	1	16.	progress	1
17.	any	1	17.	quasi	1
18.	are	1	18.	science	3
19.	can	1	19.	software	3
20.	now	1	20.	studies	1
21.	the	1	21.	varied	1
22.	many	2			
23.	much	1			
24.	till*	1			
25.	upon	1			

$$n_1 = 25, \quad n_2 = 21, \quad N_1 = 53, \quad N_2 = 28$$

Pages 2 and 3 Stage 2.1

Time July 12, 1977 09:51 - 10:02 T = 11 min

1.	0	1	33.	should	1	1.	best	10
2.	1	2	34.	would	1	2.	clarity	2
3.	2	1	35.	whether	<u>1</u>	3.	complete	2
4.	3	1			96	4.	cost	1
5.	4	1				5.	debug	1
6.	5	1				6.	determine	1
7.	6	1				7.	effective	1
8.	7	1				8.	effort	1
9.	8	1				9.	errors	1
10.	9	1				10.	increasing	1
11.	10	1				11.	know	2
12.	11	1				12.	language	2
13.	12	1				13.	list	1
14.	13	1				14.	measure	1
15.	14	1				15.	memory	1
16.	15	1				16.	modularize	1
17.	u.c.	19				17.	new	1
18.	)	16				18.	organize	1
19.	.	1				19.	predict	3
20.	-	1				20.	present	1
21.	a	1				21.	problems	1
22.	be	2				22.	program	1
23.	is	1				23.	programmers	3
24.	of	1				24.	programming	1
25.	or	1				25.	programs	1
26.	to	15				26.	requirements	1
27.	are	1				27.	select	1
28.	how	5				28.	specs	2
29.	not	1				29.	time	1
30.	use	1				30.	train	1
31.	way	9				31.	unsolved	<u>1</u>
32.	much	1						49

$$\eta_1 = 35, \quad \eta_2 = 31, \quad N_1 = 96, \quad N_2 = 49$$

Page 4 Stage 2.2

Time July 12, 1977 10:09 - 10:13 T = 4.3 min

1.	1	1	1.	aeronautical	1
2.	2	2	2.	chem	2
3.	3	1	3.	dynamics	1
4.	4	1	4.	ee	1
5.	5	1	5.	engineering	5
6.	)	6	6.	fields	1
7.	u.c.	22	7.	fluid	1
8.	<del>A</del>	3	8.	materials	1
9.	.	1	9.	mechanical	1
10.	~	1	10.	mechanics	1
11.	-	2	11.	natural	1
12.	of	$\frac{1}{42}$	12.	physics	1
			13.	power	1
			14.	science	1
			15.	strength	1
			16.	thermodynamics	1
			17.	vs	1

$$n_1 = 12, \quad n_2 = 17, \quad N_1 = 42, \quad N_2 = 22$$

Page 5 Stage 2.3

Time July 12, 1977 10:13.3 - 10:20 T = 6.7 min

1.	1	1	1.	accepted	1
2.	2	1	2.	basis	1
3.	3	2	3.	experiments	1
4.	4	1	4.	explaining	1
5.	5	1	5.	independent	1
6.	)	6	6.	long	1
7.	u.c.	6	7.	paradigms	1
8.	,	1	8.	predicting	1
9.	as	2	9.	previous	1
10.	be	1	10.	replaced	1
11.	of	1	11.	require	1
12.	on	1	12.	results	1
13.	or	1	13.	succeed	1
14.	are	5	14.	theorems	1
15.	but	1	15.	theories	5
16.	may	1	16.	twisted	1
17.	not	2	17.	unexpected	1
18.	the	1	18.	used	1
19.	they	3	19.	wrong	$\frac{1}{23}$
20.	because	$\frac{1}{39}$			

$$n_1 = 20, \quad n_2 = 19, \quad N_1 = 39, \quad N_2 = 23$$

Page 6 Stage 2.4

Time July 12, 1977 10:20 - 10:24 T = 4 min

1.	1	1	1.	allocatable	1
2.	2	6	2.	B	2
3.	3	1	3.	C	1
4.	4	2	4.	circuits	1
5.	5	1	5.	compression	1
6.	6	1	6.	e	2
7.	7	1	7.	english	1
8.	8	1	8.	f	1
9.	9	1	9.	file	1
10.	10	1	10.	i	1
11.	11	1	11.	impurities	1
12.	12	1	12.	j	1
13.	13	1	13.	L	4
14.	u.c.	24	14.	N	2
15.	subscript	6	15.	resources	1
16.	supscript	5	16.	technical	1
17.	greek	3	17.	V	6
18.	=	6	18.	$\lambda$	1
19.	$\approx$	1	19.	$\eta$	$\frac{2}{31}$
20.	$\wedge$	2			
21.	*	5			
22.	,	1			
23.	( )	15			
24.	+	2			
25.	/	2			
26.	log	$\frac{1}{92}$			

$$\eta_1 = 26, \quad \eta_2 = 19, \quad N_1 = 92, \quad N_2 = 31$$



Page 7 Stage 2.5

Time July 12, 1977 10:24 - 10:26.2 T = 2.2 min

1.	1	1	1.	counting	1
2.	2	1	2.	effort	1
3.	3	1	3.	errors	1
4.	4	1	4.	language	1
5.	5	2	5.	levels	1
6.	u.c.	8	6.	methods	1
7.	)	6	7.	modulativity	1
8.	.	5	8.	studies	$\frac{1}{8}$
9.	of	$\frac{1}{26}$			

$$\eta_1 = 9, \quad \eta_2 = 8, \quad N_1 = 26, \quad N_2 = 8$$

Pages 8 and 9 Smooth Version of Stage 2, Tuple 1  
 Time July 12, 1977 3:27 - 3:48 T = 21 min

<u>OPTR</u>			<u>OPERAND</u>		
1.	1	10	1.	ambiguities	1
2.	2	4	2.	best	5
3.	3	4	3.	clarity	1
4.	4	4	4.	completeness	1
5.	5	4	5.	complexity	1
6.	u.c.	41	6.	concentration	1
7.	)	20	7.	constraints	1
8.	<del>7</del>	24	8.	definitely	1
9.	?	3	9.	determine	1
10.	-	4	10.	effect	5
11.	.	7	11.	engineering	1
12.	a	1	12.	error	1
13.	b	1	13.	fluency	1
14.	c	1	14.	fronts	1
15.	d	1	15.	function	5
16.	e	1	16.	implementation	1
17.	as	5	17.	incompatibilities	1
18.	of	9	18.	job	1
19.	on	1	19.	language	2
20.	or	2	20.	level	1
21.	to	5	21.	maintenance	1
22.	and	2	22.	man	1
23.	way	5	23.	memory	1
24.	many	$\frac{1}{160}$	24.	mix	1
			25.	modularity	1
			26.	months	1
			27.	needs	1
			28.	obtain	1
			29.	optimizing	1
			30.	organization	1
			31.	present	1
			32.	problem	1
			33.	productivity	2

OPERAND

34.	program	1
35.	programmer	1
36.	progress	1
37.	rates	2
38.	reliability	1
39.	required	1
40.	resolve	2
41.	scheduling	1
42.	selection	1
43.	size	1
44.	software	1
45.	specifications	1
46.	specs	1
47.	substantial	1
48.	team	1
49.	testing	1
50.	training	1
51.	urgently	1
52.	volume	1
53.	vs	$\frac{1}{69}$

$$n_1 = 24, \quad n_2 = 53, \quad N_1 = 160, \quad N_2 = 69$$

Page 10 Smooth Version of Stage 2, Tuple 2  
 Time July 12, 1977 4:12 - 4:23 T = 11

<u>OPTR</u>			<u>OPERAND</u>	
1.	2	6	1. aeronautical	1
2.	u.c.	18	2. chemical	1
3.	$\Phi$	5	3. chemistry	1
4.	.	7	4. complete	1
5.	,	3	5. discipline	1
6.	-	1	6. dynamics	3
7.	" "	2	7. electrical	1
8.	)	6	8. electrodynamics	1
9.	=>	5	9. engineering	6
10.	a	2	10. fluid	1
11.	b	1	11. grounded	1
12.	c	1	12. hard	1
13.	d	1	13. materials	1
14.	e	1	14. mechanical	1
15.	be	2	15. mechanics	1
16.	in	1	16. natural	1
17.	it	1	17. power	1
18.	of	1	18. rest	1
19.	to	1	19. quasi	1
20.	and	1	20. science	1
21.	any	1	21. strength	1
22.	for	1	22. thermo	$\frac{1}{29}$
23.	must	1		
24.	upon	$\frac{1}{70}$		

$$n_1 = 24, \quad n_2 = 22, \quad N_1 = 70, \quad N_2 = 29$$

Page 11 Smooth Version of Stage 2, Tuple 3

Time July 13, 1977 8:37 - 9:12 (14 min interrupt) T = 21 min

1.	3	1	1.	base	1	28.	theories	5
2.	u.c.	6	2.	become	1	29.	theory	1
3.	<del>A</del>	5	3.	complete	1	30.	unlike	1
4.	)	6	4.	confirmation	1	31.	unrecognized	1
5.	.	1	5.	continue	1	32.	used	$\frac{1}{39}$
6.	k	3	6.	eliminated	1			
7.	a	3	7.	engineering	1			
8.	b	1	8.	experimental	1			
9.	c	1	9.	important	1			
10.	d	1	10.	inadequacies	1			
11.	e	1	11.	independent	1			
12.	be	2	12.	insight	1			
13.	by	1	13.	mathematical	1			
14.	to	1	14.	mere	1			
15.	are	2	15.	models	1			
16.	but	1	16.	natural	1			
17.	can	1	17.	new	2			
18.	for	1	18.	phenomena	2			
19.	not	1	19.	predict	1			
20.	now	1	20.	previously	1			
21.	into	1	21.	provide	1			
22.	must	1	22.	provides	1			
23.	such	1	23.	recognized	1			
24.	they	1	24.	require	1			
25.	when	1	25.	science	1			
26.	never	1	26.	software	2			
27.	until	$\frac{1}{47}$	27.	theorems	1			

$$n_1 = 27, \quad n_2 = 32, \quad N_1 = 47, \quad N_2 = 39$$

Pages 12 and 13 Smooth Version of Stage 2, Tuple 4

Time July 13, 1977 9:12 - 9:23, 9:34 - 9:46 T = 25 min

1.	¶	30	1.	advanced	1	26.	operating	1
2.	u.c.	29	2.	B	1	27.	ostapho	1
3.	)	33	3.	basic	1	28.	poly	1
4.	*	5	4.	bohrer	1	29.	prose	1
5.	=	7	5.	circuits	1	30.	relationships	2
6.	=	2	6.	clarity	1	31.	S	1
7.	+	3	7.	E	5	32.	science	1
8.	,	1	8.	Elshoff	1	33.	Shooman	1
9.	-	5	9.	experimental	1	34.	sizes	1
10.	~	2	10.	G	1	35.	system	1
11.	/	7	11.	GM	1	36.	software	1
12.	.	2	12.	gotos	1	37.	T	1
13.	font greek	12	13.	IBM	1	38.	technical	1
14.	subs	20	14.	Illinois	1	39.	V	5
15.	sups	6	15.	impurities	1	40.	verifications	1
16.	log	4	16.	independent	2	41.	η	$\frac{10}{67}$
17.	0	1	17.	insights	1			
18.	1	10	18.	L	2			
19.	2	22	19.	language	1			
20.	3	6	20.	learning	1			
21.	4	6	21.	love	1			
22.	5	5	22.	metrics	1			
23.	a	1	23.	modularity	1			
24.	b	1	24.	N	6			
25.	c	1	25.	NY	1			
26.	d	1						
27.	e	$\frac{1}{223}$						

$$\eta_1 = 27, \quad \eta_2 = 42, \quad N_1 = 223, \quad N_2 = 67$$

Page 14

Time July 13, 1977 9:48 - 10:05 17 min

<u>OPTR</u>			<u>OPRND</u>					
1.	u.c.	18	1.	confirm	1	26.	Elshoff	1
2.	#	15	2.	counting	3	27.	experimental	1
3.	.	5	3.	definition	2	28.	internal	1
4.	)	13	4.	definitions	2	29.	new	1
5.	1	2	5.	distributions	2	30.	old	1
6.	2	2	6.	effect	1	31.	probe	1
7.	3	1	7.	english	2	32.	Zweben	<u>1</u>
8.	4	1	8.	frequency	1			52
9.	5	1	9.	indicated	1			
10.	a	4	10.	language	1			
11.	as	1	11.	languages	3			
12.	in	2	12.	mechanisms	1			
13.	of	5	13.	methodology	2			
14.	to	1	14.	methods	1			
15.	for	1	15.	operator	5			
16.	-	2	16.	parse	2			
17.	b	2	17.	programming	1			
18.	c	2	18.	specific	1			
19.	d	1	19.	statistical	2			
20.	from	<u>1</u>	20.	studies	5			
		80	21.	study	1			
			22.	theoretical	2			
			23.	trees	2			
			24.	variations	1			
			25.	versus	1			

$$n_1 = 20, \quad n_2 = 31, \quad N_1 = 80, \quad N_2 = 52$$

Page 15

Time July 13, 1977 10:05 - 10:18

T = 13 min

<u>OPTR</u>			<u>OPRND</u>					
1.	u.c.	10	1.	algorithm	1	25.	statistical	1
2.	<del>φ</del>	6	2.	benefit	1	26.	studies	6
3.	)	5	3.	benefits	1	27.	special	1
4.	.	4	4.	changing	1	28.	trade	1
5.	-	3	5.	cost	1	29.	used	1
6.	1	1	6.	costs	1	30.	variances	1
7.	2	1	7.	counting	1	31.	various	1
8.	3	1	8.	detailed	1	32.	versus	2
9.	4	1	9.	design	1	33.	widely	$\frac{1}{47}$
10.	5	2	10.	effect	1			
11.	A	3	11.	general	2			
12.	b	1	12.	given	1			
13.	of	7	13.	higher	1			
14.	on	1	14.	important	1			
15.	to	1	15.	language	3			
16.	and	1	16.	languages	3			
17.	for	1	17.	level	2			
18.	the	1	18.	means	1			
19.	within	1	19.	off	1			
20.	all	$\frac{1}{52}$	20.	parameter	1			
			21.	practices	1			
			22.	proposed	1			
			23.	programming	1			
			24.	purpose	3			

$$n_1 = 20, \quad n_2 = 33, \quad N_1 = 52, \quad N_2 = 47$$



Page 16

Time July 13, 1977 10:18 - 10:34 T = 16 min

1.	u.c.	17	1.	author	1	25.	remove	1
2.	<del>A</del>	5	2.	base	1	27.	repeat	1
3.	)	7	3.	bases	1	28.	S	2
4.	,	1	4.	basic	1	29.	sharpen	1
5.	.	3	5.	bugs	1	30.	significantly	1
6.	^	3	6.	clarity	1	31.	statistical	1
7.	-	1	7.	data	2	32.	studies	1
8.	" "	1	8.	definitions	1	33.	study	1
9.	1	1	9.	delivered	1	34.	T	4
10.	2	1	10.	discovery	1	35.	variance	1
11.	3	1	11.	effect	1	36.	variances	$\frac{1}{43}$
12.	4	1	12.	effort	1			
13.	5	1	13.	error	1			
14.	A	1	14.	errors	1			
15.	C	1	15.	estimating	1			
16.	by	1	16.	experiments	1			
17.	in	1	17.	individual	1			
18.	of	4	18.	large	2			
19.	on	2	19.	need	1			
20.	and	5	20.	non	1			
21.	for	2	21.	obtain	1			
22.	between	$\frac{2}{62}$	22.	parameter	1			
			23.	programmer	1			
			24.	programmers	1			
			25.	rate	2			

$$\eta_1 = 22, \quad \eta_2 = 36, \quad N_1 = 62, \quad N_2 = 43$$

Page 17

Time July 13, 1977 10:34 - 10:45 T = 11 min

OPTR

1.	u.c.	15	1.	analyze	2
2.	$\mathcal{A}$	10	2.	E	1
3.	)	13	3.	effect	1
4.	.	1	4.	english	1
5.	*	1	5.	expand	1
6.	sup	1	6.	hours	1
7.	font greek	1	7.	L	1
8.	1	1	8.	large	1
9.	2	1	9.	methods	1
10.	3	1	10.	minutes	1
11.	4	1	11.	modularity	1
12.	5	1	12.	presentation	1
13.	8	1	13.	problem	1
14.	10	1	14.	programs	1
15.	a	1	15.	resultant	1
16.	b	1	16.	small	1
17.	c	1	17.	specifications	1
18.	d	2	18.	start	1
19.	e	2	19.	statements	1
20.	in	1	20.	study	1
21.	of	1	21.	task	1
22.	to	2	22.	tasks	2
23.	with	$\frac{1}{61}$	23.	technical	1
			24.	V	2
			25.	$\lambda$	$\frac{1}{28}$

$$n_1 = 23, \quad n_2 = 25, \quad N_1 = 61, \quad N_2 = 28$$

Page 20

Time July 18, 1977 09:30 - 9:58 T = 28 min

<u>OPTR</u>			<u>OPRND</u>								
1.	u.c.	13	26.	yet	1	1.	able	1	26.	obtaining	1
2.	<i>A</i>	2	27.	even	1	2.	ambiguities	1	27.	optimal	1
3.	.	8	28.	many	1	3.	area	1	28.	present	2
4.	,	4	29.	only	1	4.	best	1	29.	problem	1
5.	-	4	30.	over	1	5.	branch	1	30.	productivity	1
6.	" "	3	31.	then	2	6.	close	1	31.	programmer	1
7.	—	2	32.	this	1	7.	complete	4	32.	programming	1
8.	<i>run</i>	2	33.	upon	1	8.	completeness	1	33.	progress	1
9.	)	2	34.	being	1	9.	cycle	1	34.	projects	1
10.	1	1	35.	might	1	10.	depends	1	35.	provide	1
11.	2	1	36.	their	1	11.	determining	1	36.	quasi	3
12.	a	4	37.	should	$\frac{1}{83}$	12.	development	1	37.	resolving	1
13.	be	2				13.	discipline	1	38.	software	3
14.	in	2				14.	engineering	4	39.	specifications	1
15.	is	3				15.	fronts	1	40.	state	1
16.	its	1				16.	full	1	41.	substantial	1
17.	of	4				17.	hand	1	42.	successful	1
18.	on	1				18.	incompatibilities	1	43.	urgently	$\frac{1}{54}$
19.	to	3				19.	large	1			
20.	and	2				20.	largely	1			
21.	but	1				21.	life	1			
22.	for	1				22.	management	1			
23.	not	1				23.	mentioned	1			
24.	the	2				24.	methods	1			
25.	way	1				25.	needed	1			

$$\eta_1 = 37, \quad \eta_2 = 43, \quad N_1 = 83, \quad N_2 = 54$$

Page 21

Time July 18, 1977 9:58 - 10:29

T = 31 min

1. u.c.	9	1. achieve	1	27. organization	1	53. Volume $\frac{1}{65}$
2. .	7	2. clarity	1	28. power	1	
3. k	9	3. complete	1	29. problem	1	
4. -	3	4. complexity	1	30. program	3	
5. )	3	5. constraints	1	31. programmer	1	
6. <i>mm</i>	2	6. discipline	1	32. programming	1	
7. 3	1	7. effect	1	33. project	1	
8. 4	1	8. engineering	1	34. provide	1	
9. 5	1	9. estimating	3	35. quantitative	2	
10. A	3	10. evaluation	1	36. quasi	1	
11. as	3	11. function	1	37. reliable	1	
12. of	3	12. goal	1	38. reliability	1	
13. or	1	13. guidelines	1	39. required	2	
14. to	1	14. hours	1	40. requirements	1	
15. and	6	15. implementation	1	41. scheduling	1	
16. any	1	16. job	1	42. selection	1	
17. are	2	17. language	2	43. size	1	
18. for	4	18. level	1	44. source	1	
19. the	2	19. maintenance	2	45. specifications	1	
20. more	1	20. man	2	46. specified	1	
21. upon	1	21. memory	1	47. subsequent	1	
22. well	2	22. methods	2	48. team	1	
23. would	$\frac{1}{67}$	23. mix	1	49. techniques	1	
		24. modularity	1	50. testing	2	
		25. needed	2	51. training	1	
		26. optimizing	1	52. versus	1	

$$\eta_1 = 23, \quad \eta_2 = 53, \quad N_1 = 67, \quad N_2 = 65$$

Page 22

Time July 18, 1977 10:29 - 10:39 T = 10 min

1. u.c.	4	27. upon	2	1. aeronautical	1	27. off	1
2. $\phi$	1	28. that	1	2. area	1	28. power	1
3. .	5	29. they	1	3. based	5	29. preceeded	1
4. ,	13	30. this	1	4. branches	4	30. provide	1
5. ;	3	31. their	1	5. cases	1	31. quantitative	1
6. -	3	32. which	1	6. competent	1	32. quasi	2
7. " "	3	33. during	1	7. complete	2	33. rest	1
8. A	1	34. should	1	8. complex	1	34. science	2
9. be	3	35. however	1	9. considered	1	35. sound	1
10. it	1	36. perhaps	$\frac{1}{79}$	10. discipline	2	36. statics	1
11. in	3			11. dynamics	2	37. stimulated	1
12. of	2			12. electrical	1	38. strength	1
13. on	4			13. electrodynamics	1	39. studies	1
14. to	1			14. engineering	6	40. therodynamics	1
15. all	2			15. example	1	41. time	1
16. and	5			16. far	1	42. trade	1
17. any	1			17. fluid	1	43. useful	1
18. are	1			18. grounded	1	44. value	1
19. but	2			19. guidelines	1	45. virtually	$\frac{1}{63}$
20. for	3			20. hard	1		
21. may	1			21. highly	1		
22. now	2			22. important	1		
23. the	1			23. less	1		
24. was	1			24. materials	1		
25. have	1			25. mechanical	1		
26. must	1			26. natural	2		

$$n_1 = 36, \quad n_2 = 45, \quad N_1 = 79, \quad N_2 = 63$$

Page 23

Time July 18, 1977 10:51 - 11:07 T = 16 min

1. u.c.	5	27. must	1	1. areas	1	26. note	1
2. <del>ff</del>	2	28. only	2	2. base	1	27. originally	1
3. .	5	29. such	1	3. become	1	28. pertinent	1
4. ,	6	30. than	1	4. body	1	29. phenomena	1
5. []	1	31. that	2	5. complete	1	30. predict	1
6. A	4	32. they	3	6. confirmation	1	31. previously	1
7. at	1	33. when	1	7. considerable	1	32. provide	2
8. be	2	34. never	1	8. continues	1	33. recognized	1
9. by	1	35. their	1	9. eliminated	1	34. relationships	1
10. in	1	36. until	1	10. engineering	1	35. require	1
11. is	2	37. which	1	11. evidence	1	36. science	1
12. it	1	38. beyond	1	12. experimental	1	37. scope	1
13. of	2	39. further	1	13. exists	1	38. shown	1
14. to	3	40. however	$\frac{1}{69}$	14. hypothesis	1	39. software	2
15. and	3			15. important	1	40. suggests	1
16. are	2			16. inadequacies	1	41. theorems	1
17. but	1			17. independent	1	42. theories	3
18. can	1			18. insight	1	43. theory	2
19. for	1			19. intended	1	44. unexpected	1
20. its	1			20. laboratory	1	45. unlike	1
21. not	1			21. mathematical	1	46. unrecognized	1
22. now	1			22. mere	1	47. used	$\frac{1}{53}$
23. one	1			23. models	1		
24. the	1			24. natural	1		
25. into	1			25. new	2		
26. more	1						

$$n_1 = 40, \quad n_2 = 47, \quad N_1 = 69, \quad N_2 = 53$$

Page 24

Time July 18, 1977 11:07 - 11:29 T = 22 min

1. u.c.	11	27. and	3	1. algorithm	1	27. operators	2
2. $\mathbb{F}$	3	28. any	2	2. based	1	28. output	1
3. .	4	29. are	2	3. basic	1	29. parameter	1
4. ()	5	30. can	1	4. call	1	30. parameters	1
5. ,	7	31. for	1	5. computer	1	31. procedure	1
6. subs	13	32. has	1	6. conceptually	1	32. program	2
7. sups	1	33. not	1	7. copy	1	33. programs	1
8. /	1	34. the	9	8. denoting	1	34. quite	1
9. +	1	35. also	1	9. directly	1	35. relation	1
10. =	1	36. been	2	10. example	1	36. relationships	1
11. *	1	37. from	1	11. fifth	1	37. required	1
12. log	2	38. have	1	12. found	2	38. science	1
13. greek	6	39. that	1	13. handful	1	39. software	1
14. 1	4	40. them	1	14. hard	1	40. sum	1
15. 2	7	41. upon	1	15. important	1	41. tend	1
16. A	4	42. among	1	16. independent	3	42. total	2
17. an	1	43. these	2	17. input	1	43. unique	3
18. as	1	44. which	$\frac{1}{122}$	18. language	2	44. usage	2
19. be	1			19. length	1	45. useful	1
20. by	1			20. measured	1	46. $\eta$	$\frac{7}{72}$
21. is	2			21. metric	1		
22. it	1			22. metrics	1		
23. of	9			23. N	6		
24. on	1			24. number	4		
25. or	1			25. obey	1		
26. to	1			26. operands	3		

$$\eta_1 = 44, \quad \eta_2 = 46, \quad N_1 = 122, \quad N_2 = 72$$

Page 25

Time July 18, 1977 11:29 - 11:40 T = 11 min

1. u.c.	15	27. has	1	1. denoting	1	27. $n$	$\frac{7}{45}$
2. $\Phi$	7	28. one	1	2. discriminations	1		
3. ()	8	29. the	5	3. E	1		
4. ,	2	30. also	1	4. elementary	1		
5. greek	8	31. been	1	5. follows	1		
6. /	3	32. from	1	6. given	1		
7. +	2	33. that	2	7. gives	1		
8. *	6	34. under	1	8. implementation	1		
9. =	4	35. which	1	9. invariant	1		
10. $\approx$	1	36. should	1	10. L	3		
11. subs	9	37. another	1	11. language	1		
12. sups	6	38. further	1	12. level	1		
13. log	2	39. least	$\frac{1}{120}$	13. mental	1		
14. 1	2			14. N	2		
15. 2	10			15. number	1		
16. a	1			16. possible	1		
17. an	1			17. potential	1		
18. as	1			18. produce	1		
19. be	1			19. program	2		
20. by	1			20. required	1		
21. is	3			21. shown	1		
22. it	2			22. sum	1		
23. of	3			23. translation	1		
24. or	1			24. V	8		
25. to	2			25. vocabulary	1		
26. and	1			26. volume	2		

$$n_1 = 39, \quad n_2 = 27, \quad N_1 = 120, \quad N_2 = 45$$



Page 26

Time July 18, 1977 11:40 - 11:45 and 12:13 - 12:28 T = 20 min

1. u.c.	17	27. that	2	1. allocatable	1	27. mental	1
2. $\Phi$	4	28. this	1	2. approximated	1	28. metrics	1
3. .	2	29. could	1	3. basic	1	29. number	2
4. ,	3	30. which	1	4. circuits	1	30. observation	1
5. =	3	31. perhaps	$\frac{1}{73}$	5. control	1	31. operating	1
6. /	3			6. data	1	32. ostapkos	1
7. ()	2			7. demonstration	1	33. programming	1
8. ,	3			8. derivable	1	34. relationships	2
9. []	2			9. derivation	1	35. rents	1
10. 18	1			10. directly	1	36. resources	1
11. A	1			11. discriminations	1	37. rule	1
12. an	1			12. E	2	38. S	3
13. be	1			13. Elcis	1	39. second	1
14. by	1			14. elementary	1	40. simultaneously	1
15. in	1			15. estimate	1	41. stroud	1
16. is	1			16. finding	1	42. systems	1
17. it	1			17. gives	1	43. T	2
18. of	5			18. governing	1	44. time	1
19. or	1			19. hardware	1	45. unforeseen	1
20. to	2			20. include	1	46. unexpected	1
21. for	1			21. initially	1	47. using	1
22. the	7			22. interesting	1	48. V	2
23. four	1			23. knowledge	1	49. versus	$\frac{1}{57}$
24. from	1			24. L	2		
25. most	1			25. leads	1		
26. must	1			26. length	1		

$$n_1 = 31, \quad n_2 = 49, \quad N_1 = 73, \quad N_2 = 57$$

Page 27

Time July 18, 1977 12:28 - 12:42 T = 14 min

1.	u.c.	20	27.	beyond	1	1.	additional	1	27.	new	2
2.	44	2	28.	itself	$\frac{1}{81}$	2.	applied	1	28.	originally	1
3.	.	2				3.	areas	1	29.	ostapko	1
4.	,	7				4.	bohrex	1	30.	overall	1
5.	" "	1				5.	clarity	1	31.	parts	1
6.	—	1				6.	classes	1	32.	polytechnical	1
7.	'	5				7.	computer	1	33.	process	1
8.	[ ]	5				8.	effect	1	34.	program	1
9.	as	1				9.	electric	1	35.	programs	1
10.	be	1				10.	Elshoff	1	36.	prose	1
11.	by	1				11.	english	1	37.	published	1
12.	of	11				12.	experimental	1	38.	purity	1
13.	or	2				13.	general	2	39.	quantitative	1
14.	to	2				14.	go	1	40.	recently	1
15.	and	2				15.	IBM	1	41.	respect	1
16.	can	1				16.	Illinois	1	42.	role	1
17.	one	1				17.	impurity	1	43.	Shooman	1
18.	the	6				18.	independent	1	44.	sought	1
19.	have	1				19.	insight	2	45.	technical	1
20.	into	1				20.	institute	1	46.	theory	1
21.	most	1				21.	learning	1	47.	tos	1
22.	some	1				22.	list	1	48.	understanding	1
23.	that	1				23.	love	1	49.	university	1
24.	well	1				24.	measurement	1	50.	various	1
25.	with	1				25.	modularity	1	51.	verifications	1
26.	might	1				26.	motors	1	52.	York	$\frac{1}{55}$

$$n_1 = 28, \quad n_2 = 52, \quad N_1 = 81, \quad N_2 = 55$$

Page 28

Time July 18, 1977 12:42 - 1:03 T = 21 min

1.	u.c.	16	27.	each	1	1.	analyze	1	27.	programmer	1
2.	H	4	28.	five	1	2.	areas	2	28.	prove	1
3.	.	5	29.	from	1	3.	benefit	1	29.	requiring	1
4.	;	8	30.	more	1	4.	cited	1	30.	respect	1
5.	—	2	31.	only	1	5.	come	1	31.	samples	1
6.	mm	2	32.	with	2	6.	cycle	1	32.	science	1
7.	)	2	33.	might	2	7.	directly	1	33.	small	1
8.	*	1	34.	which	1	8.	english	1	34.	software	1
9.	greek	1	35.	while	1	9.	follow	1	35.	specific	1
10.	sup	1	36.	should	1	10.	gather	1	36.	specifications	1
11.	1	1	37.	perhaps	$\frac{1}{84}$	11.	hours	1	37.	start	1
12.	2	1				12.	immediately	1	38.	statements	1
13.	5	1				13.	implement	1	39.	steps	1
14.	8	1				14.	improvement	1	40.	studies	1
15.	10	1				15.	indicated	1	41.	substantial	2
16.	a	2				16.	introduction	1	42.	task	1
17.	as	1				17.	L	1	43.	tasks	2
18.	be	1				18.	life	1	44.	technical	1
19.	in	3				19.	management	1	45.	useful	1
20.	of	3				20.	mind	1	46.	V	2
21.	to	5				21.	minutes	1	47.	n	$\frac{1}{52}$
22.	we	1				22.	N	1			
23.	and	2				23.	needing	1			
24.	can	1				24.	number	2			
25.	one	2				25.	obtaining	1			
26.	the	3				26.	problem	1			

$$n_1 = 37, \quad n_2 = 47, \quad N_1 = 84, \quad N_2 = 52$$

Page 29

Time July 18, 1977 1:03 - 1:17 T = 14 min

1.	u.c.	1	1.	actual	1	27.	statement	1
2.	ff	5	2.	analysis	1	28.	study	2
3.	.	6	3.	calculated	2	29.	sufficiently	1
4.	,	1	4.	comparable	1	30.	techniques	1
5.	)	5	5.	different	1	31.	times	1
6.	~~~~~	2	6.	effect	1	32.	variances	1
7.	1	1	7.	expand	1	33.	warrent	<u>1</u>
8.	2	1	8.	experiments	1			39
9.	3	1	9.	important	1			
10.	4	1	10.	individual	1			
11.	5	1	11.	investigations	1			
12.	a	1	12.	large	2			
13.	to	2	13.	methods	1			
14.	of	3	14.	note	1			
15.	on	2	15.	perform	1			
16.	and	2	16.	problem	1			
17.	are	1	17.	productivity	1			
18.	the	5	18.	programmer	2			
19.	that	1	19.	programming	1			
20.	between	<u>1</u>	20.	programs	3			
		48	21.	relationships	1			
			22.	repeat	1			
			23.	resultant	1			
			24.	resulting	1			
			25.	scale	1			
			26.	similarly	1			

$$n_1 = 20, \quad n_2 = 33, \quad N_1 = 48, \quad N_2 = 39$$

Page 30

Time July 18, 1977 1:17 - 1:32 T = 15 min

1.	u.c.	5	27.	would	1	1.	actually	1	27.	programs	1
2.	<del>94</del>	3	28.	should	2	2.	average	2	28.	quantitative	1
3.	.	3	29.	between	$\frac{1}{56}$	3.	base	1	29.	rate	1
4.	,	2				4.	based	1	30.	significantly	1
5.	)	3				5.	calculated	1	31.	statistical	1
6.	3	1				6.	concentration	1	32.	studies	1
7.	4	1				7.	contribute	1	33.	T	1
8.	a	2				8.	data	1	34.	times	1
9.	be	2				9.	deviations	1	35.	values	2
10.	by	1				10.	discovery	1	36.	variance	2
11.	it	1				11.	E	1	37.	yield	$\frac{1}{43}$
12.	of	5				12.	effect	2			
13.	on	2				13.	error	1			
14.	to	3				14.	expected	1			
15.	all	1				15.	fluency	1			
16.	and	2				16.	illuminating	1			
17.	for	2				17.	language	1			
18.	the	4				18.	large	1			
19.	been	1				19.	level	1			
20.	from	1				20.	measure	2			
21.	have	1				21.	new	1			
22.	this	2				22.	observed	2			
23.	upon	1				23.	obtain	1			
24.	very	1				24.	perform	1			
25.	their	1				25.	programmers	1			
26.	since	1				26.	programming	1			

$$\eta_1 = 29, \quad \eta_2 = 37, \quad N_1 = 56, \quad N_2 = 43$$

Page 31

Time July 18, 1977 1:17 - 1:32 T = 15 min

1.	u.c.	10	27.	further	$\frac{1}{62}$	1.	analysis	1	27.	program	1
2.	4	5				2.	aptitude	1	28.	programming	1
3.	.	3				3.	area	1	29.	prose	1
4.	,	1				4.	base	1	30.	rates	1
5.	/	1				5.	benefit	1	31.	relationships	1
6.	" "	1				6.	bugs	1	32.	repetition	1
7.	)	4				7.	calculated	1	33.	require	1
8.	[ ]	1				8.	consisting	1	34.	science	1
9.	~~~~~	2				9.	data	1	35.	sharpening	1
10.	1	1				10.	definition	1	36.	software	3
11.	2	1				11.	delivered	1	37.	technical	1
12.	3	1				12.	determine	1	38.	testing	1
13.	4	1				13.	development	1	39.	use	1
14.	5	1				14.	error	1	40.	used	1
15.	a	3				15.	estimated	1	41.	variance	1
16.	be	1				16.	expected	1	42.	widely	1
17.	by	2				17.	experiments	1	43.	Zislis	$\frac{1}{46}$
18.	of	9				18.	following	1			
19.	to	1				19.	investigate	1			
20.	and	1				20.	investigations	1			
21.	the	4				21.	language	1			
22.	most	1				22.	large	1			
23.	that	1				23.	modularity	1			
24.	this	1				24.	observed	1			
25.	might	3				25.	paragraph	1			
26.	between	1				26.	possibility	1			

$$n_1 = 27, \quad n_2 = 43, \quad N_1 = 62, \quad N_2 = 46$$

Page 32

Time July 18, 1977 1:54 - 2:06 T = 12 min

1.	u.c.	5	27.	well	1	1.	additional	1	27.	specifications	1
2.	94	2	28.	others	1	2.	area	1	28.	task	1
3.	.	4	29.	because	1	3.	concentrating	1	29.	time	1
4.	,	9	30.	however	$\frac{1}{63}$	4.	consequently	1	30.	used	$\frac{1}{31}$
5.	)	2				5.	determine	1			
6.	mm	2				6.	follows	1			
7.	1	1				7.	example	1			
8.	5	1				8.	independent	1			
9.	a	2				9.	information	1			
10.	as	1				10.	involves	1			
11.	be	2				11.	job	1			
12.	in	2				12.	language	1			
13.	is	2				13.	number	1			
14.	it	3				14.	other	1			
15.	of	3				15.	parameters	1			
16.	to	3				16.	points	1			
17.	all	1				17.	practice	1			
18.	and	1				18.	principle	1			
19.	any	1				19.	productivity	1			
20.	but	1				20.	programmer	2			
21.	for	1				21.	related	1			
22.	not	1				22.	required	1			
23.	the	4				23.	requires	1			
24.	two	1				24.	scheduling	1			
25.	even	1				25.	simple	1			
26.	that	3				26.	software	1			

$$n_1 = 30, \quad n_2 = 30, \quad N_1 = 63, \quad N_2 = 31$$

Page 33

Time July 18, 1977 2:06 - 2:17 T = 11 min

1.	u.c.	4	27.	the	5	1.	ambiguities	1	27.	statement	2
2.	¶	2	28.	been	1	2.	basic	1	28.	suggests	1
3.	.	3	29.	must	1	3.	but	1	29.	T	1
4.	,	6	30.	that	2	4.	complete	2	30.	time	1
5.	" "	1	31.	with	1	5.	computer	1	31.	unique	1
6.	)	4	32.	which	1	6.	conceptually	1	32.	warranted	1
7.	/	1	33.	another	1	7.	constraints	1	33.	λ	1
8.	greek	2	34.	between	1	8.	contains	1	34.	η	$\frac{1}{37}$
9.	subs	1	35.	without	1	9.	contradictions	1			
10.	sup	1	36.	furthermore	1	10.	existence	1			
11.	*	1	37.	nevertheless	$\frac{1}{61}$	11.	fluent	1			
12.	2	1				12.	input	1			
13.	a	3				13.	intensive	1			
14.	an	1				14.	investigation	1			
15.	be	1				15.	language	1			
16.	in	1				16.	level	1			
17.	is	1				17.	memory	1			
18.	it	1				18.	no	1			
19.	of	2				19.	number	1			
20.	or	1				20.	observed	1			
21.	and	1				21.	operands	1			
22.	for	2				22.	output	1			
23.	has	1				23.	problem	2			
24.	may	1				24.	programmer	1			
25.	not	1				25.	relationship	1			
26.	one	1				26.	start	1			

$$n_1 = 37, \quad n_2 = 34, \quad N_1 = 61, \quad N_2 = 37$$



Page 34

Time July 18, 1977 2:28 - 2:45 T = 17 min

1.	u.c.	16	27.	for	1	1.	algebraically	1	27.	S	2
2.	<b>H</b>	3	28.	has	1	2.	algorithm	1	28.	somewhere	1
3.	.	3	29.	its	1	3.	appears	2	29.	T	1
4.	,	5	30.	one	3	4.	characterized	1	30.	translated	1
5.	( )	1	31.	the	3	5.	consequently	2	31.	V	5
6.	=	4	32.	from	1	6.	considerable	1	32.	value	1
7.	*	3	33.	near	1	7.	decreases	1	33.	variance	1
8.	/	2	34.	this	1	8.	defined	1	34.	volume	1
9.	sup	5	35.	when	1	9.	given	1	35.	$\lambda$	$\frac{5}{52}$
10.	greek	5	36.	which	1	10.	increase	1			
11.	2	1	37.	while	1	11.	increases	1			
12.	3	1	38.	within	1	12.	interest	1			
13.	a	4	39.	another <sup>I</sup>	$\frac{91}{91}$	13.	invariant	1			
14.	an	1				14.	L	4			
15.	as	3				15.	language	4			
16.	be	1				16.	languages	1			
17.	by	1				17.	large	1			
18.	in	1				18.	level	1			
19.	is	3				19.	lie	1			
20.	it	1				20.	mean	1			
21.	of	3				21.	number	1			
22.	to	3				22.	parameters	1			
23.	and	1				23.	potential	1			
24.	any	1				24.	product	1			
25.	but	1				25.	programming	1			
26.	can	1				26.	results	1			

$$n_1 = 39, \quad n_2 = 35, \quad N_1 = 91, \quad N_2 = 52$$

Page 35

Time July 18, 1977 2:45 - 3:00 T = 15 min

1.	u.c.	5	27.	well	1	1.	analysis	1	27.	new	1
2.	H	1	28.	with	1	2.	available	1	28.	programs	1
3.	.	6	29.	could	2	3.	based	1	29.	programming	1
4.	,	3	30.	might	1	4.	benefits	1	30.	proposed	1
5.	—	1	31.	should	1	5.	change	1	31.	purpose	2
6.	greek	1	32.	within	1	6.	confidence	1	32.	question	1
7.	a	2	33.	because	1	7.	cost	1	33.	samples	1
8.	an	1	34.	therefore	$\frac{1}{64}$	8.	data	1	34.	serve	1
9.	be	3				9.	determinations	1	35.	single	1
10.	in	1				10.	different	1	36.	small	2
11.	is	1				11.	effect	1	37.	special	1
12.	it	3				12.	extended	1	38.	statistical	1
13.	of	9				13.	general	1	39.	studies	1
14.	on	1				14.	higher	1	40.	study	1
15.	or	1				15.	include	1	41.	trade	1
16.	to	2				16.	increases	1	42.	used	1
17.	and	1				17.	interest	1	43.	variances	1
18.	any	2				18.	investigations	1	44.	versus	2
19.	can	1				19.	language	4	45.	$\lambda$	$\frac{1}{51}$
20.	for	1				20.	languages	1			
21.	not	1				21.	level	1			
22.	the	4				22.	made	1			
23.	also	1				23.	mean	1			
24.	then	1				24.	means	1			
25.	this	1				25.	methodologies	1			
26.	upon	1				26.	off	1			

$$\eta_1 = 34, \quad \eta_2 = 45, \quad N_1 = 64, \quad N_2 = 51$$

Page 36

Time July 18, 1977 :00 - 3:17 T = 17 min

1.	u.c.	9	27.	this	1	1.	additional	1	27.	program	4
2.	.	4	28.	with	1	2.	ambiguous	1	28.	provided	1
3.	,	9	29.	indeed	1	3.	appears	1	29.	quantitative	1
4.	)	1	30.	rather	1	4.	approach	1	30.	quite	1
5.	<u>      </u>	6	31.	however	$\frac{1}{81}$	5.	case	1	31.	recent	1
6.	[ ]	1				6.	considerable	1	32.	reduce	1
7.	3	1				7.	costs	2	33.	required	1
8.	an	2				8.	develop	1	34.	respect	1
9.	be	1				9.	discriminations	1	35.	results	1
10.	by	1				10.	Gordon	1	36.	science	1
11.	if	1				11.	E	4	37.	sense	1
12.	in	3				12.	effect	1	38.	shown	1
13.	is	3				13.	elementary	1	39.	software	1
14.	it	2				14.	final	2	40.	spent	1
15.	of	8				15.	implementation	2	41.	time	2
16.	or	1				16.	improve	1	42.	usual	1
17.	to	4				17.	improving	1	43.	value	3
18.	can	1				18.	increase	1	44.	versus	1
19.	for	1				19.	increasing	1	45.	work	$\frac{1}{58}$
20.	has	1				20.	interesting	1			
21.	the	10				21.	legibility	1			
22.	who	1				22.	likely	1			
23.	does	1				23.	maintenance	1			
24.	from	1				24.	measure	2			
25.	than	1				25.	optimizing	1			
26.	that	2				26.	problem	1			

$$n_1 = 31, \quad n_2 = 45, \quad N_1 = 81, \quad N_2 = 58$$

Page 37

Time July 18, 1977 3:17 - 3:27

T = 10 min

1.	u.c.	2	1.	advantageously	1
2.	H	2	2.	amount	1
3.	.	2	3.	clarity	3
4.	,	2	4.	depending	1
5.	—	1	5.	determined	1
6.	a	4	6.	effort	3
7.	be	3	7.	increasing	1
8.	in	1	8.	made	1
9.	is	1	9.	maintenance	1
10.	it	2	10.	measure	3
11.	of	4	11.	needs	1
12.	to	2	12.	polished	1
13.	but	1	13.	program	1
14.	for	1	14.	quantitative	1
15.	not	1	15.	represents	1
16.	the	5	16.	suggests	1
17.	that	1	17.	total	1
18.	then	2	18.	understand	1
19.	this	1	19.	used	1
20.	upon	1	20.	write	$\frac{1}{26}$
21.	could	3			
22.	which	1			
23.	before	$\frac{1}{44}$			

$$n_1 = 23, \quad n_2 = 20, \quad N_1 = 44, \quad N_2 = 26$$

Page 19 Abstract

Time July 19, 1977 4:10 - 4:23

T = 13 min

<u>OPTR</u>			<u>OPRND</u>					
1.	u.c.	1	1.	abstract	1	26.	science	4
2.	4+	1	2.	areas	1	27.	several	1
3.	.	3	3.	basis	1	28.	software	5
4.	,	2	4.	branches	1	29.	specific	1
5.	—	1	5.	brief	1	30.	suggesting	1
6.	a	2	6.	concludes	1	31.	suggestions	$\frac{1}{41}$
7.	in	2	7.	corresponding	1			
8.	of	7	8.	development	1			
9.	and	3	9.	disciplines	1			
10.	are	2	10.	discussion	1			
11.	for	1	11.	engineering	3			
12.	the	4	12.	guidance	1			
13.	into	1	13.	insight	1			
14.	some	2	14.	listed	1			
15.	then	1	15.	maintenance	1			
16.	well	1	16.	natural	2			
17.	with	1	17.	needs	1			
18.	after	1	18.	paper	1			
19.	might	1	19.	present	1			
20.	their	1	20.	presented	1			
21.	which	1	21.	problems	1			
22.	between	$\frac{1}{48}$	22.	provide	1			
			23.	recent	1			
			24.	relations	1			
			25.	results	1			

$$\eta_1 = 22, \quad \eta_2 = 31, \quad N_1 = 48, \quad N_2 = 41$$