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PHASE RELATIONS ASSOCIATED WITH MATHEMATICAL SCIENCES: A Case Study

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An analysis of quantitative data on the incidence of phase relations associated with mathematical sciences is presented. It has been found that application and bias phase relations have high percentage of incidence. Physical sciences show a greater tendency for phase relations with mathematics. It is also observed that intra-subject phase relations with mathematics is fairly frequent.

0 Introduction

Complex subjects have been identified as one of the important features in the structure and development of universe of subjects. They arise out of the mode of "loose assemblage" (3). The resulting relation is called "Phase Relation (5). In phase relation, two or more subjects are combined by a variety of relations such as Bias, Application, Influence and also Comparison, Difference and General (5). Detailed definitions of this typology has been presented in Colon Classification (= CC) and also in some papers (1,2,4). However to get data on the frequency of incidence of phase relations in different subject fields, we have to identify a large collection of documents, principally in a library. In this paper, we have attempted to find out the types of phase relations incident in documents collected in a large scientific library. We have further restricted our study to the phase relations of subjects associated with Mathematical Sciences.

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1 The nature of Mathematical Sciences

Mathematical Sciences is a field which generates a kind of abstract logic. It attempts to find patterns from empirical situations and generalize them into a principle or a function. Such generalisations are helpful for applications to solve problems in different contexts. In a sense, specialists express difficult concepts and multivariate relational complexities with the help of mathematical language. The field of mathematics is an ancient one. It has developed from Arithmetics, Algebra and Geometry to the current developments of Statistical analysis, Operations Research and Topology. In fact, it is said that mathematics is a discipline whose structure is ever changing and developing. Mathematics has been used as a general input discipline to the study of the relations and critical factors in these relations in various subject fields. Such studies aid prediction and improve the rigour of the field of study for further development.

In order to get a feel of the ramifications of the use of mathematics in different fields, we have attempted to get a sample set of documents from a large library for analysis.

2 Methodology by collecting the samples

To get an empirical sample of documents which embody complex subjects associated with mathematics, we selected a large science library in Bangalore, namely the Indian Institute of Science Library. This library has a collection of books which range 1,15,000. Amidst these documents mathematics has around 7000 documents. Of these documents, 3000 documents are those published during 1960 to 1980. From this collection, we selected a sample of subjects which have phase relations with Mathematical Sciences. The procedure of the selection of the documents for the purpose of study is as follows:

1) The alphabetical part of the catalogue, containing subject entries were scanned. The entry term normally used was mathematics or any of its associated fields such as Algebra, Geometry, Statistics, Calculus etc. From this part call numbers for various documents indicating phase relations were selected.

2) Using the call numbers selected, the classified part was searched for the specific main entries representing documents having complex subjects. In this process, the entire classified part was

searched. Fields in Natural Sciences and Social Sciences were looked into for connections with nmathematical sciences.

3) For each main entry selected as a sample for the study of phase relations, the following items of information were collected:

a) DDC call number of the document;

b) Title of the document;

c) Edition and/or the year of publication of the document;

d) Subject headings wherever they were provided.

4) The collected samples totalled to 576. Of these 223 were published during 1960's (1960-1969) and 293 were published during 1970's (1970-1981). Tl ey were analysed as follows:

a) The actual documents on the shelf were also consulted for determining the specific subject embodied in it;

b) Each of these specific subjects was analysed using postulational approach to classification.

c) The type of phase relations involved was identified and noted on each slip;

d) The component subjects involved in the phase relations were also noted. For this purpose, the classification schemes such as the Dewey Decimal Classification (DDC), C.C. and the Broad System of Ordering (BSO) were used, for recognising the subjects.

e) The total data collected from the samples was consolidated in the following manner:

i) By types of phase relations namely General, Bias, Application and Influence;

ii) By subjects involved in phase relation;

iii) By the date of publication of documents. For this purpose, we selected documents which were published after 1960 upto 1980's.

The consolidated data and inferences that can be drawn from this data are presented in this paper.

3 Subjects involved in the phase relations

From the samples collected, it was found that a fairly wide spectrum of subjects have phase relations involving Mathematical Sciences. This spectrum ranges from Physical Sciences, Natural Sciences to Social Sciences. The following tables present the quantitative data on incidence of various types of phase relations with Mathematical Sciences.

TABLE 1. Main subject fields and the number of phase relations in it.

Sl. No.	Main Subject Divisions	No. of phase relations
1	Sciences (In General)	45
2	Mathematical Sciences	178
3	Physical Sciences	174
4	Chemical Sciences	16
5	Biological and Medical Sciences	34
6	Social Sciences	57
7	Management Sciences	78
8	Computer Science	54
	Total Phase Relations	636

TABLE 2. Subjects having phase relations with Mathematical Sciences

Sl. No.	Name of the Subject	No. of phase relation
1	Information and communication theory	4
2	Computer Science	54
3	Science (General)	45
4	Mathematics	111
5	Statistics	67
6	Astronomy	1
7	Physics	66
8	Engineering	105
9	Chemistry	12
10	Chemical Technology	4
11	Biological Sciences	20
12	Earth Sciences	2
13	Agriculture	
14	Medicine	8

Sl. No.	Name of Subject	No. of Phase relation
15	Behavioural Sciences	4
16	Philosophy	1
17	Psychology	3
18	Social Sciences	4
19	Education	6
20	Political Science	3
21	Economics	22
22	Management Science	60
23	Commerce/Business	18
	Total	636

Note for the Tables: It is important here to note that a single document having more than one complex subject has been counted seprately, hence resulting 636 phase relations out of the sample containing 516 entries.

Annotation:

It is evident from the above two tables that the complex subjects going with mathematical sciences has a fairly high incidence, namely 178 instances out of 636 relations. This indicates that interrelations in mathematics have a high internal incidence, that is a subfield in Mathematics is used for the study of another subfield. Physical sciences have ranked second in phase relations with Mathematics (it has 174 phase relations). Here again, it is found that Engineering has the highest incidence (105). The third field which uses mathematics is Management Science. Social sciences rank fourth in having interrelations with mathematical sciences. Ranked in discending sequence of their interrelations, we can list the following subjects namely, Computer Science, Sciences in general, Biological and Medical Science and Chemical Sciences. It is obvious that the Physical and Natural Science sector uses mathematics more than Social Sciences Sector. It may be cautioned that the data is collected from a predominantly Science and Technology library and hence there is slant in the incidence of phase relations.

4 Analysis of data by phase relations

The phase relations incident in the sample subject chosen for study are General, Bias, Application and Influence. There was no

incidence of comparison and difference phase relations in the sample. Further it can be stated that the dominant phase relations were bias phase relations and application phase relations. The succeding sections discuss the details of the various phase relations.

41 General Phase Relation

The following table presents details about the incidence of general phase relation of the complex subjects associated with mathematical sciences. By general relation it is meant that the two subjects are yet to get into any kinds of dynamic relations such as Bias, Applications and Influence. For example the following title is considered to have general phase relation. "Algebraic methods in the global theory of complex spaces. 1976".

TABLE 3. Complex Subjects having general phase relations with Mathematical Sciences

Sl. No.	Subject	Number of General Phase Relation	
		1960s	1970s
1	Information and communication theory	—	1
2	Computer Science	1	7
3	Mathematics	36	28
4	Statistics	20	18
5	Physics	2	5
6	Engineering	—	2
7	Chemistry	—	1
8	Agriculture	1	3
9	Social Science	—	1
10	Political Science	2	—
11	Economics	1	—
12	Management Science	5	11
13	Commerce/Business	1	—
	Total	69	77

Annotation:

146 instances of general phase relations have been found out of the sample of 516 documents. The 1970's indicate slightly higher

incidence than that in the 1960s. The mathematics itself has a fairly high incidence of general phase relation with mathematical sciences. Apart from this the field of statistics has a high incidence of general phase relations. The social sciences appear to have very low incidence of general phase relation.

42 Bias Phase Relation

Bias phase relation appears to be one of the commonest incidences of phase relations. In this relations the subject appearing in the first phase is oriented to the needs of the subjects appearing in the second phase. For example the following subject is said to have bias phase relation.

"Numerical Methods for Engineers and Scientists. 1977." The following table presents quantitative data on the incidence of bias phase relation of different subject fields with Mathematical Sciences.

TABLE 4. Complex Subjects having Bias Phase relation with mathematical sciences.

Sl. No.	Subject	No. of bias phase relations	
		1960s	1970s
1	Computer Science	1	12
2	Science (General)	13	15
3	Mathematics	4	5
4	Statistics	—	5
5	Physics	4	9
6	Engineering	27	25
7	Chemistry	1	5
8	Biological Sciences	7	5
9	Agriculture	1	—
10	Medicine	1	3
11	Behavioural Sciences	1	1
12	Psychology	1	—
13	Social Sciences	3	7
14	Education	1	1
15	Economics	5	6
16	Management Science	9	8
17	Commerce/Business	1	4
	Total	80	111

Annotation

Bias phase relation has a fairly large incidence in the complex subjects studied in the sample. There are about 191 instances of bias phase relations out of 516 documents. The 1970's indicates a slight increase of bias phase relations. Engineering fields appear to have fairly high percentage of incidence of bias phase relation. Sciences (General) comes next in order. Social sciences have a sprinkling of bias phase with economics having a large share in this. It can also be observed that computer sciences have a large incidence of bias phase relations in 1970s.

43 Application Phase Relation

Mathematics is an important field for the study of many disciplines. This is well borne out in the sample chosen. Almost all the fields of knowledge have fairly good incidence of application phase relation with mathematical sciences. For example, the following document illustrates the nature of applied phase relation with Mathematics. "Group theory and its applications to Physical Problems".

The following table presents the quantitative data of the complex subjects associated with mathematics.

TABLE 5. Complex Subjects having Application Phase Relations with Mathematical Sciences.

Sl. No.	Subject	No. of Application phase relation	
		1960's	1970's
1	Information & Communication theory	2	1
2	Computer Science	11	20
3	Science (General)	8	9
4	Mathematics	10	9
5	Statistics	6	10
6	Astronomy	—	1
7	Physics	22	23
8	Engineering	27	19
9	Chemimistry	—	4
10	Chemical Technology	2	2
11	Biological Sciences	2	6
12	Earth Sciences	—	2

Sl. No.	Subject	No. of Application phase relation	
		1960's	1970's
13	Agriculture	1	—
14	Medicine	1	3
15	Behavioural Sciences	1	
16	Philosophy	1	—
17	Psychology	2	—
18	Social Sciences	—	3
19	Education	2	2
20	Political Science	1	—
21	Economics	3	6
22	Management Science	5	17
23	Commerce/Business	3	6
	Total	110	144

Annotation:

Application phase relation has the highest incidence — that is above 250 instance out of 516 documents chosen as sample. The 1970's show slight increase in the percentage of application phase relation of complex subjects with mathetical sciences. Engineering and Physics appears to have high incidence of application phase relation. Social sciences also have good incidence of the phase relation. Apart from this the computer sciences appear to have a good share of this phase relation with mathematics. Further the 1970's indicate larger incidence with computer science.

44 Influence Phase Relation

Influence phase relation is a relation in which the subject field in the first phase is influenced by the structure and development of the subject in the second phase. For example, "Selecting and Ordering of Population: Influence of Statistical Methods. 1976".

The following table presents data on the incidences of influence phase relation in the complex subjects associated with mathematical sciences.

TABLE 6 Complex Subjects having Influence Phase Relations with Mathematical Sciences.

Sl. No.	Subject	No. of influence phase relations	
		1960s	1970s
1	Computer Science	—	2
2	Mathematics	7	12
3	Statistics	2	6
4	Physics	—	1
5	Engineering	1	4
6	Chemistry	—	1
7	Economics	—	1
8	Management Science	—	5
9	Commerce/Business	1	2
	Total	11	34

Annotation:

The data indicates that the influence phase relation is internal to mathematics. The large percentage of influence phase relation is shared by mathematical sciences themselves. Engineering and Management Sciences rank next in the sequence. It may also be observed that influence phase relation is on the increase in its incidence in the 1970s.

5 Overall Analysis

The incidence of phase relations in the complex subjects associated with Mathematical Sciences appears to be significant though not dominate one. Roughly out of the 3000 mathematical documents (published after 1960's), we find 516 documents having phase relations. Even there we find application phase relation has a dominant position followed by bias phase relation (See tables 7 and 8 in the Annexure). It may be observed that this may be due to the abstract nature of mathematics and its utility for application in different contexts. In fact mathematics in general is used as an objective language for analysis of the problems in various fields of knowledge.

6 Conclusion

This paper presents a case study to analyse empirically the incidence of documents with phase relations in the collections of libraries. It is obvious that we cannot generalise the inferences on the basis of the sample data provided in this paper. But it is an attempt to apply a methodology to find the ramifications in the incidences of complex subjects and the type of phase relations. It may be helpful to collect data from the collections of other large libraries oriented to science and technology as well as social sciences. Such data collection may help us to develop a quantitative pattern of incidence of complex subjects in the universe of subjects.

7 Bibliographic References

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8 Annexures

TABLE 7. Phase relations in Mathematical Sciences (Total No. of documents 516).

Phase Relation	Number of Documents	
	1960's (1960-1969)	1970's (1970-1981)
General	66	69
Bias	56	82
Application	88	111
Influence	10	31
Total	223	293

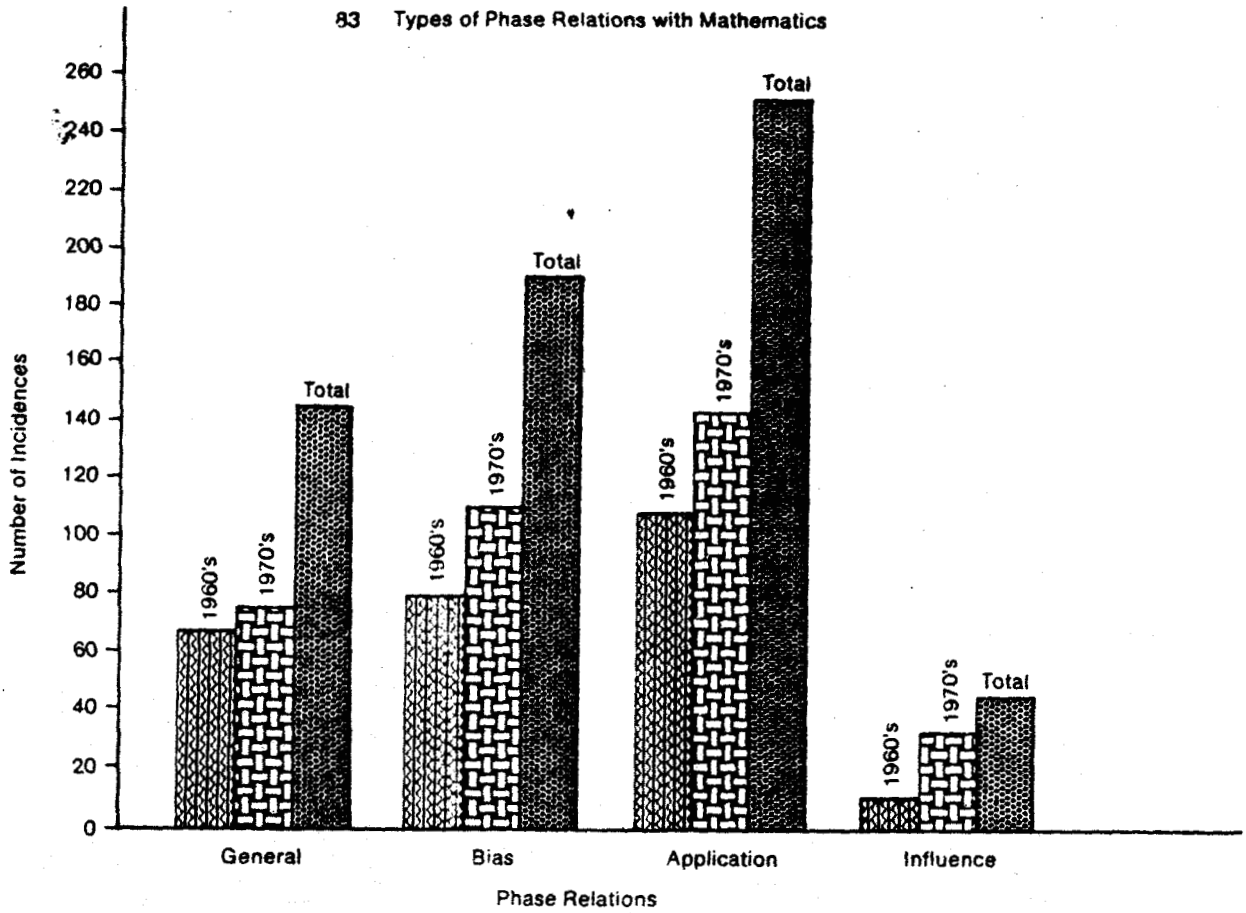
NB. (1) Different editions of the same document by the same author in the same period are treated as one document.

(2) When more than one Conference/Seminar is taking place on a subject successively in the same period, it is also treated as one Conference. (eg. Conference on Application of Logic to Algebra and Arithmetic, 1979; Proceedings).

TABLE 8. Phase Relations in Mathematical Sciences

Sl. No.	Phase Relation	General		Bias		Application		Influence		Total
	Phase relation with	1960's	1970's	1960's	1970's	1960's	1970's	1960's	1970's	
1	Information and Communication theory	–	1	–	–			–	–	4
2	Computer Sciences	1	7	1	12	11	20	–	2	54
3	Science (General)	–	–	13	15	8	9	–	–	45
4	Mathematics	36	28	4	5	10	9	7	12	111
5	Statistics	20	18	–	5	6	10	2	6	67
6	Astronomy	–	–	–	–	–		–	–	1
7	Physics	2	5	4	9	22	23	–	1	66
8	Engineering	–	2	27	25	27	19	1	4	105
9	Chemistry	–	1	1	5	–	4	–		12
10	Chemical Technology	–	–	–	–	2	2	–	–	4
11	Biological Sciences	–	–	7	5	2	6	–	–	20
12	Earth Sciences	–	–	–	–	–	2	–	–	2
13	Agriculture	1	3	1	–	1	–	–	–	6
14	Medicine	–	–	1	3	1	3	–	–	8
15	Behavioural Sciences	–	–	1	1	1	1	–	–	4
16	Philosophy	–	–	–	–	1	–	–	–	1
17	Psychology	–	–	1	–	2	–	–	–	3
18	Social Sciences	–	1	3	7	–	3	–	–	14
19	Education	–	–	1	1	2	2	–	–	6
21	Economics	1	–	– 5	6	3	6	–	1	22
22	Management Science	5	11	9	8	5	17	–	5	60
23	Commerce/Business	1	–	1	4	3	6	1	2	18
	Total	69	77	80	111	144	11	34	636	

83 Types of Phase Relations with Mathematics



84 SUBJECT FIELDS IN PHASE RELATIONS WITH MATHEMATICS