Chapter 6

Citation Pattern of Theses submitted by PRL Students

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CITATION PATTERN OF THESES SUBMITTED BY PRL STUDENTS

In recent years, study of research has become an important activity for many universities and research institutes. The most reliable way to know the contribution of research to the world knowledgebase is through publication and citation statistics. The research papers and doctoral theses are the instruments through which results of the research are communicated to outside world. Both these scholarly publications conclude with the list of references. The study of these references (citations) gives an idea about the development of any research topic or a researcher and also indicates the kind of literature referred by the researchers.

In one of the early citation studies, Gross and Gross (1927), discovered that very few journals were cited frequently in the *Journal of the American Chemical Society*, while many journals were only cited once. This observation helped the librarians to build the serial collection such that libraries are able to fulfill most of the needs of the users with a small amount of journals.

The last two chapters dealt with the research output in the form of publications in journals, conference proceedings and invited talks delivered by the scientist of PRL. The present chapter analyses another form of research output – Theses - of the doctoral students of PRL during 1997-2006. It does the citation analysis of the bibliographies present in the end of theses submitted by the Ph. D. students.

At this juncture, it would help the reader if the few terms used are reiterated briefly. Citation analysis is a practical tool to evaluate the library's collection in meeting the

information needs of its users. It is particularly useful because of the interdisciplinary nature of research these days and the heavy reliance on journals. Information obtained about journals not owned can be used in collection management decisions in the future. If the need arises to make cuts to serials budgets and librarians are forced to cancel titles, this data can be used to find the least cited material. This method may also be used if the library needs money to purchase the archives of more heavily used journals (La Bonte, 2005).

Another term which requires elaboration is Dissertation or thesis. Thesis is a document submitted in support of candidature for a degree or professional qualification presenting the author's research and findings. Boyer (1973) describes it as "the capstone to a formal academic training process." Though the doctorate has existed since the Middle Ages, it was only at the beginning of the 19th century that the Ph. D. degree became a diploma associated to the production of original scientific research and the training of new researchers (Lariviere, 2008). Barry (1997) adds that successful doctoral students tend to be "comprehensive and up to date in reviewing the literature." Consequently, their dissertations provide a large amount of bibliographic information useful not only to other researchers but to librarians as well. It gives a pointer to the collection being used by the doctoral students. Keeping this in mind, in addition to the fact that theses comprise an important component of the research output of a research institute, the researcher undertook the study of the doctoral theses submitted by PRL students during 1997-2006.

The present chapter aims to find the change in the citing pattern over the years from 1997 to 2006 for print and electronic documents. It also identifies the most preferred type of resource used by the doctoral students at PRL – journal articles, books, reports, proceedings, etc. The data available is used to see whether the ratio of subscribed to non-subscribed journals remained the same in the 10 year period and to identify the most used journals in each subject division.

Procedure used for citation analysis

By 2001 many of the publishers had started providing electronic version free with print journals and Open Access documents had also started appearing on the horizon. The access to the electronic versions of many journals was provided by giving hyperlinks through the PRL Library homepage. As mentioned in chapter three, the period of the study of 10 years (1997-2006) has been chosen due to the fast changing technological developments (multimedia, multi-formats) in scholarly communications. The study took into consideration this change and divided the 10 year period into two slabs – pre ejournal (1997-2000) and ejournal (2001-2006) periods and tries to find out what effect this transition had on the citing pattern in the doctoral theses.

The Annual Reports for the years 1997-2006 - the basic authentic resource yielded the information that sixty eight theses were submitted during the 10 year study period. No theses were submitted in 2003. These 68 theses comprised the sample of the study. The bibliographies compiled at the end of the doctoral theses have been studied to find out the type of resources being used – books, journal articles, proceedings of a conference, monographs, reports, doctoral theses, etc.

Bibliography sections were photocopied from each of the 68 theses. Information extracted from each included doctoral student's name, year of graduation, year of cited work, journal title of each citation, other type of resources like books, reports, proceedings, monographs, theses, etc. The journal names were then tagged for 'Subscribed title' or 'Non-subscribed title'. The source for the information was the holdings data of the Library. The files of all the theses in each year were combined, so as to see the pattern of 'subscribed or non-subscribed journals in each year.

The entire sample was also classified as 'Print' and 'Electronic' documents. The source for this information was subscription invoices and license agreements of the publishers. Care was taken to consider the backfiles access given by the publisher at the time of subscription. Under electronic documents were CDs and online documents. The study tries to find out if any pattern emerges as regards the use of print and electronic resources from

1997 through 2006. To find out most used unique titles, the files were merged according to the division so as to get the count of journals referred, in each subject field.

Use of Library Resources

The 68 theses submitted during 1997-2006 yielded a total of 10,864 citations. Thus on an average each thesis contained 160 references. Table 3.1 shows that there is a marked increase in number of references in the e-journal period. The reason could be the ease of use of e-re sources as compared to print resources.

Table 3.1 : Number of Citations per thesis

Years	Total no. of citations	No. of Theses	No. of Citations/thesis
1997-2000	4250	29	147
2001-2006	6614	39	170

Tables 3.2 – 3.10 indicate the pattern of use of resources by the PRL doctoral students for their research work.

Electronic vs. Print Resources

Table 3.2 gives the use of electronic vs. print documents during 1997-2000. During this period e-resources had just started appearing on the web and print resources dominated the scene completely as is evident with 2.16% electronic resources and 97.84% print resources being cited by the students. Fig 3.1 and Fig 3.2 is the graphical representation of overall use and pattern of usage through the years 1997-2000 respectively.

Table 3.2 : Use of documents : Electronic vs. Print during 1997-2000

Document	1997	1998	1999	2000	Total	%
Electronic	16	0	1	75	92	2.16
Print	1148	1752	782	476	4158	97.84

Fig 3.1 : Use of documents - Electronic vs. Print during 1997-2000

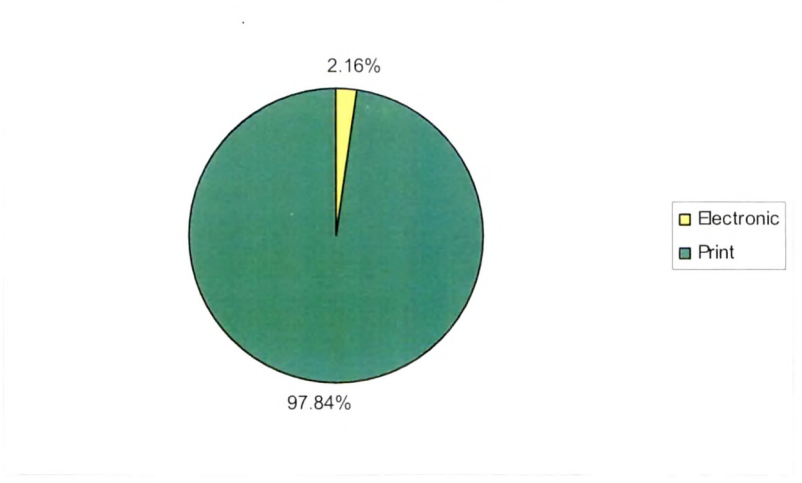


Fig 3.2 : Year wise pattern of use of documens – Electronic vs. Print from 1997-2000

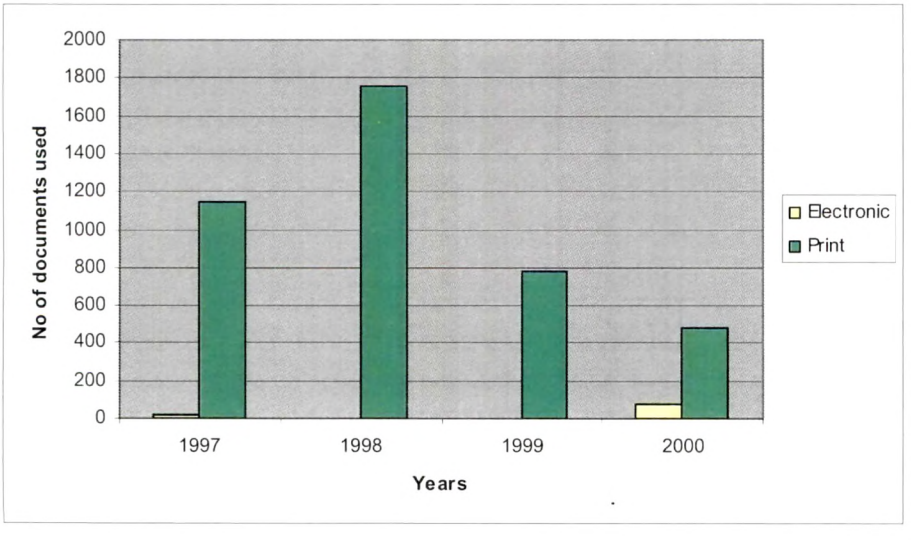


Table 3.3 and Figures 3.3 and 3.3a give the break up of electronic vs. print documents cited by the students during 2001-2006. There is a stark difference between the two time period slabs. The electronic documents now take up 33.76% and print documents take up 66.24% share from the total number of citations.

Table 3.3 : Use of documents : Electronic vs. Print during 2001-2006

Document	2001	2002	2004	2005	2006	Total	%
Electronic	243	306	1023	336	325	2233	33.76
Print	1488	409	1559	538	387	4381	66.24

Fig 3.3 : Use of documents – Electronic vs. Print during 2001-2006

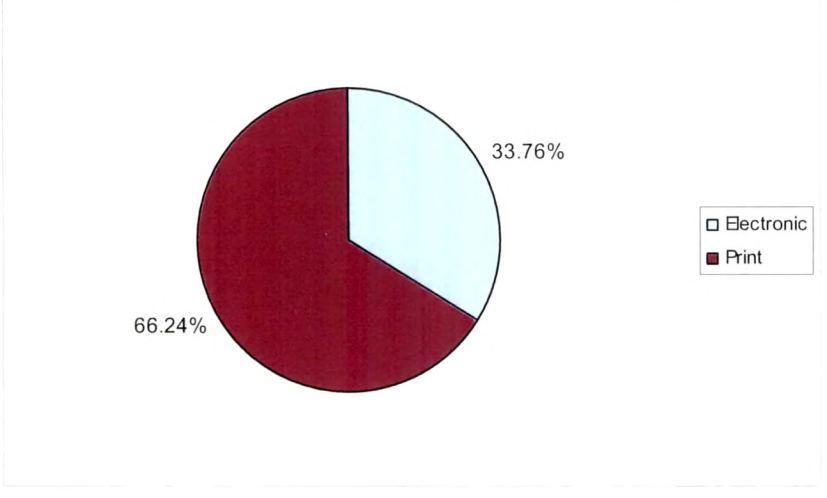
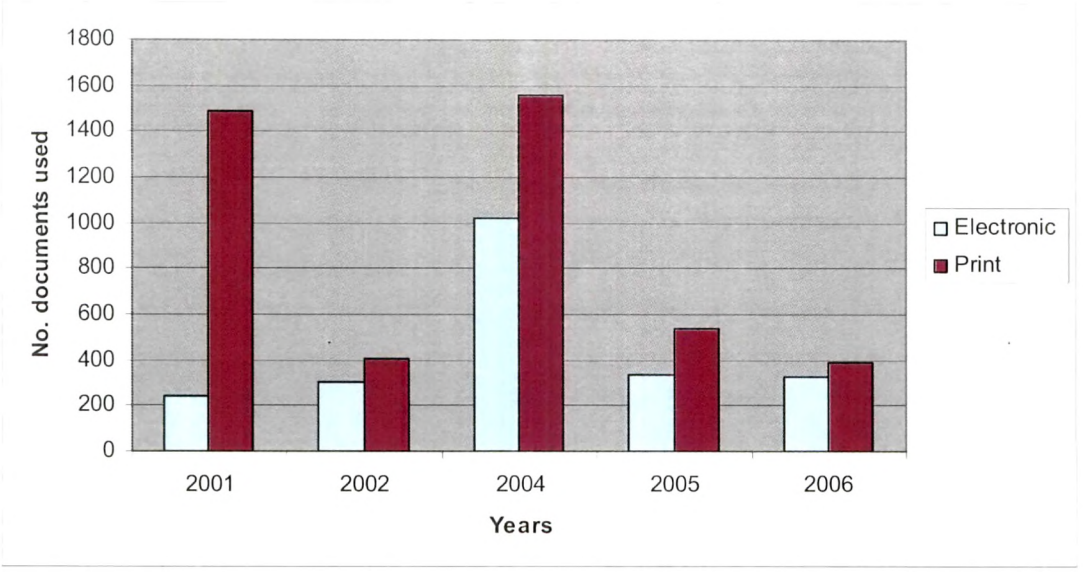


Fig 3.3a : Year wise pattern of use of documents – Electronic vs. Print from 2001-2006



It is evident from the above figure that the difference between the use of Electronic and Print resources is decreasing over the years 2001-2006 and by 2006 it had decreased so much that they seem to be almost equal.

Types of Documents cited

Table 3.4 and Figures 3.4 and 3.4a give the break up of different types of documents cited by the students during 1997-2000. Journals form the major chunk with 84.05% followed by Books (10.78 %) and Other Documents (5.18%).

Table 3.4 : Use of different types of documents during 1997-2000

Documents	1997	1998	1999	2000	Total	%
Journals	927	1531	652	462	3572	84.05
Books	170	142	81	65	458	10.78
Other Docs.	67	79	50	24	220	5.18

Fig 3.4 : Use of different types of documents during 1997-2000

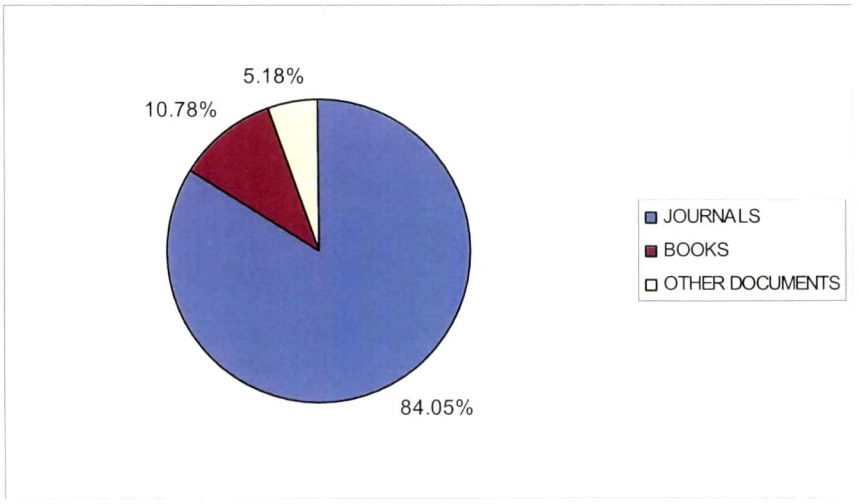


Fig 3.4a : Year wise pattern of use of types of documents during 1997-2000

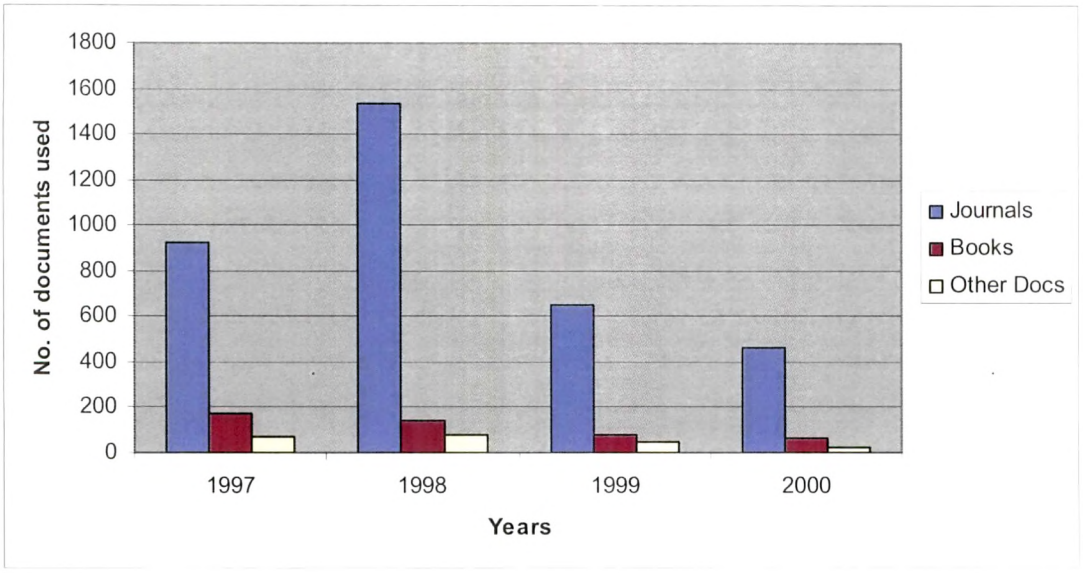


Table 3.5 and Figures 3.5 and 3.5a give the data on types of documents cited during 2001-2006. It shows that there is a slight increase in proportion of books being cited in 2001-2006 (10.89% as against 10.78% in 1997-2000) and slight decrease in Journals and Other Documents (from 84.05% to 84.03% and 5.18% to 5.08% respectively).

Table 3.5 : Use of different types of documents during 2001-06

	2001	2002	2004	2005	2006	Total	%
Journals	1456	612	2187	728	575	5558	84.03
Books	165	55	300	98	102	720	10.89
Other Docs.	110	48	95	48	35	336	5.08

Fig 3.5 : Use of different types of documents during 2001-2006

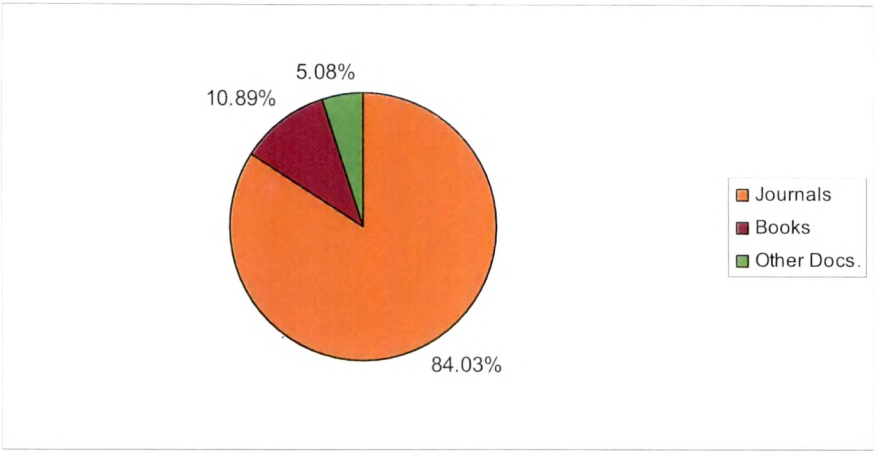
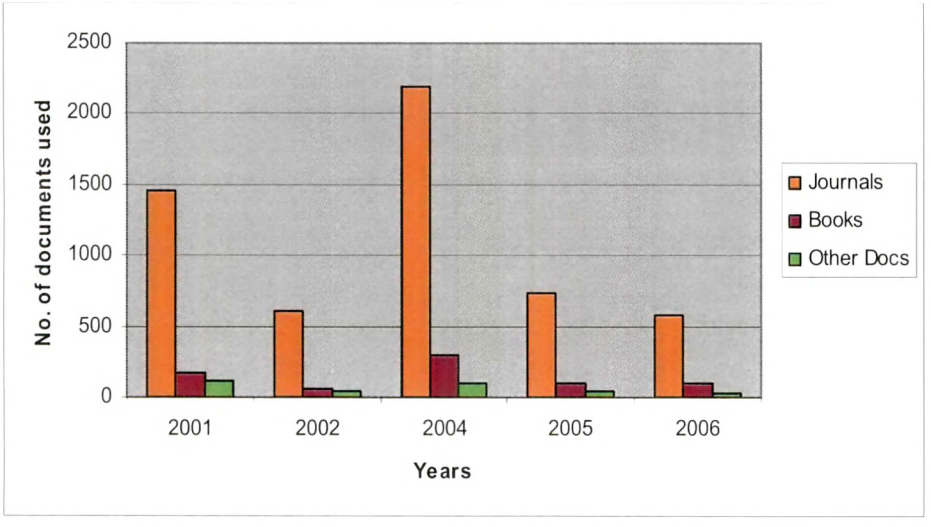


Fig 3.5a : Year wise pattern of use of different types of documents from 2001-2006



The above figures clearly indicate that in both the time slabs, the percentage of journals, books and other documents has remained constant at about 84%, 11% and 5% respectively. This result confirms the findings of earlier studies (Buttlar, 1999 and Gooden, 2001).

Journals cited : Non-subscribed vs. Subscribed

As seen from tables 3.4 and 3.5, Journals are the most preferred type of documents used by the doctoral students at PRL, as is the case the world over. It makes up for almost 84% of all the documents cited. Out of 9,130 total journal citations (84%), the researcher wanted to find the proportion of non-subscribed and subscribed journals cited by the students during pre-ejournal and ejournal period. Out of the total of 3,572 journal citations during pre-ejournal period of 1997-2000, 586 citations (16.41%) are from non-subscribed titles and 2,986 citations (83.59 %) are from subscribed titles.

Table 3. 6 : Use of journals – Non-subscribed vs. Subscribed during 1997-2000

Journals	1997	1998	1999	2000	Total	%
Non-subscribed	151	241	75	119	586	16.41
Subscribed	776	1290	577	343	2986	83.59

Fig 3.6 : Use of Journals – Non-subscribed vs. Subscribed during 1997-2000

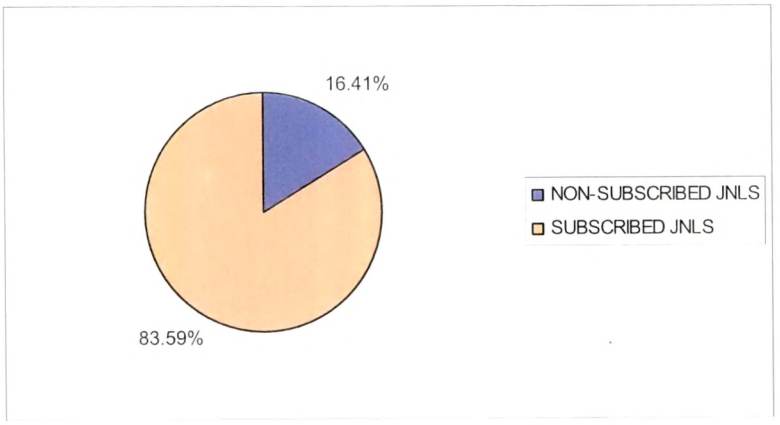


Fig 3.6a : Year wise pattern of journals used : Non-subscribed vs. Subscribed from 1997-2000

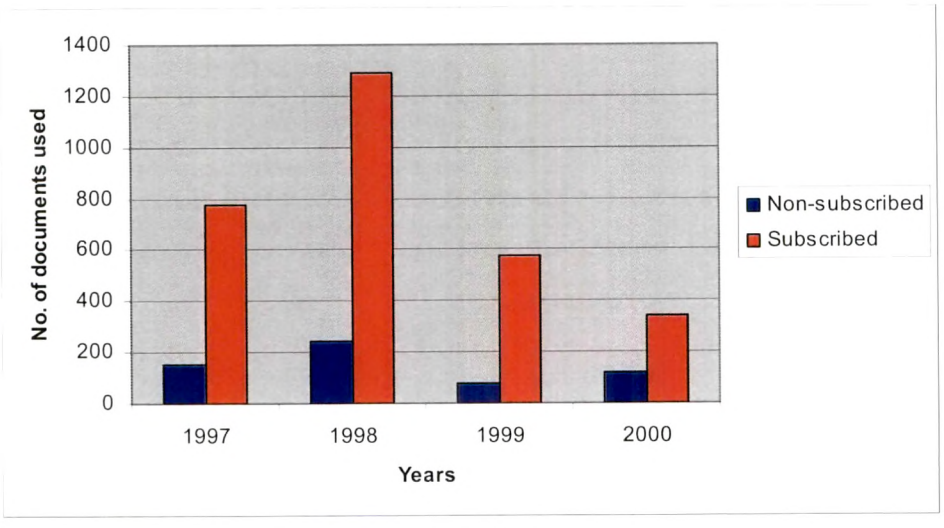


Table 3.7 and Figures 3.7 and 3.7a below give the information about the journals cited – Non subscribed vs. Subscribed during 2001-2006. Out of 5,558 journal citations during 2001-06, 1,033 citations (18.59 %) are from non-subscribed journals and 4,525 citations (81.41 %) are from subscribed journals. Comparing the pre-e-journal and e-journal periods, there is a clear cut increase of 2.18 % in the proportion of non-subscribed titles cited in the e-journal time period of 2001-2006.

Table 3.7 : Use of Journals - Non-subscribed vs. Subscribed during 2001-2006

Journals	2001	2002	2004	2005	2006	Total	%
Non-subscribed	218	79	399	174	147	1033	18.30
Subscribed	1238	533	1788	554	428	4525	81.70

Fig 3.7 : Use of journals - Non-subscribed vs. Subscribed during 2001-2006

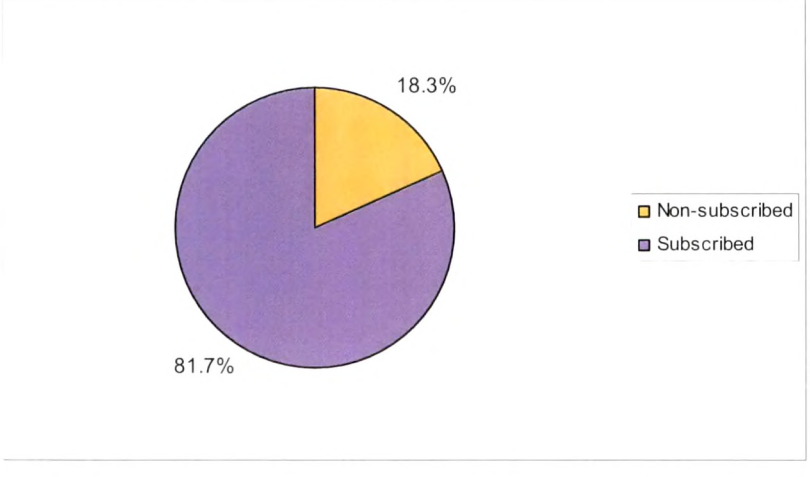
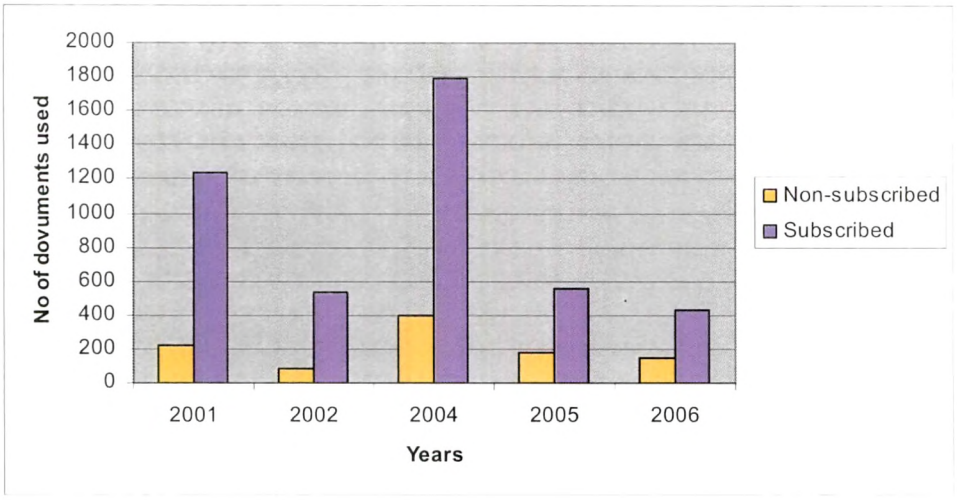


Fig 3.7a : Year wise pattern of use of journals – Non-subscribed vs. Subscribed from 2001-2006



The reason for increased use of non-subscribed journals in the e-journal time slab could be the quick access to articles received through friends in other institutes/countries and Document Delivery Service provided by the Library.

Other Documents cited

As seen from tables 3.4 and 3.5, 'Other Documents' make up for about 5% of the total documents cited by the doctoral students. The researcher wanted to find out which category of 'Other Documents' are preferred by the students and whether there was any change in the category preference in the two different time slabs. Most of the other documents are very commonly used except Eprints and Monographs. Eprints were mentioned in chapter 4 as a quick mode of communicating the research results to the peer community before presenting them in a conference or publishing in a journal. A monograph is similar to a book but deals with one specific topic in great detail. It is

usually written by a single author. Normally the term is used for a work intended to be complete at a level more advanced than that of a textbook.

Table 3.8 and Figures 3.8 and 3.8a give the data of 'Other documents' cited by the doctoral students during 1997-2000. Conference Proceedings (45.45%) are the most cited documents amongst the 'Other Documents' followed by Reports (28.18 %) during the pre-ejournal period of 1997-2000.

Table 3.8 : Use of 'Other documents' during 1997-2000

Other Docs.	1997	1998	1999	2000	Total	%
Eprint	16	0	1	2	19	8.64
Monograph	1	5	0	1	7	3.18
Proceedings	24	39	28	9	100	45.45
Report	20	29	5	8	62	28.18
Thesis	6	6	16	4	32	14.55

Fig 3.8 : Use of 'Other documents' during 1997-2000

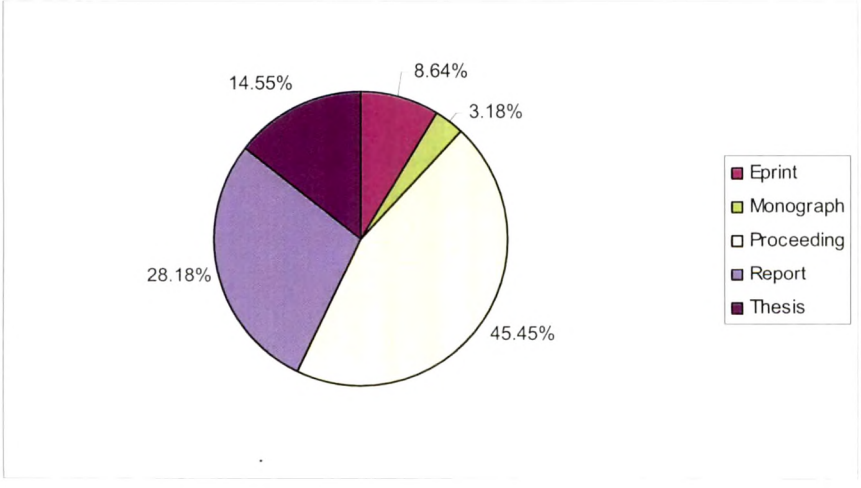
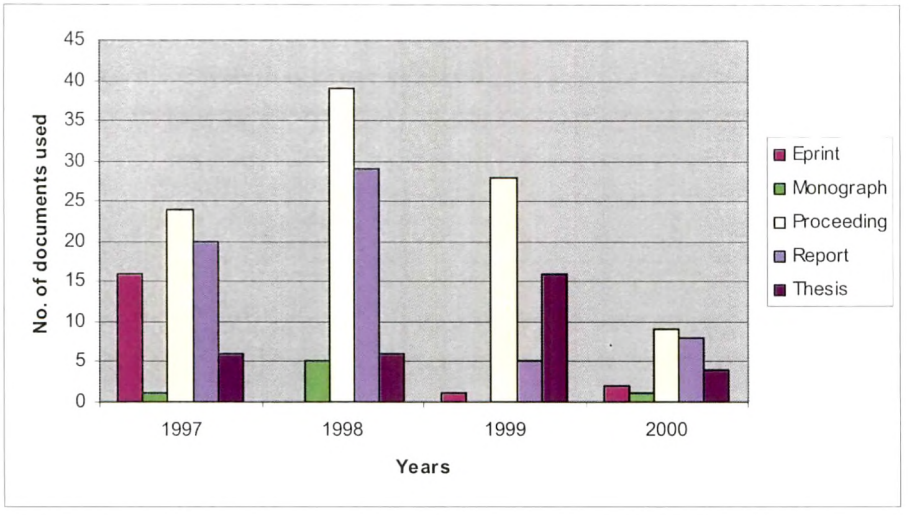


Fig 3.8a : Year wise pattern of use of 'Other documents' from 1997-2000



Thus Monographs and Eprints are the least used resources during the pre-ejournal period.

Table 3.9 and Figures 3.9 and 3.9a below give data of use of other documents during 2001-2006. In this period, Reports account for 44.35% and Conference Proceedings make up 28.57% of total 'other documents' used by the students during the course of their study.

Table 3.9 : Use of 'Other documents' during 2001-2006

Other Docs.	2001	2002	2004	2005	2006	Total	%
Eprint	1	4	12	10	2	29	8.63
Monograph	7	3	1	2	4	17	5.06
Proceedings	45	3	31	11	6	96	28.57
Report	43	33	39	18	16	149	44.35
Standard	0	0	0	0	1	1	0.30
Thesis	14	5	12	7	6	44	13.10

Fig 3.9 : Use of 'Other Documents' during 2001-2006

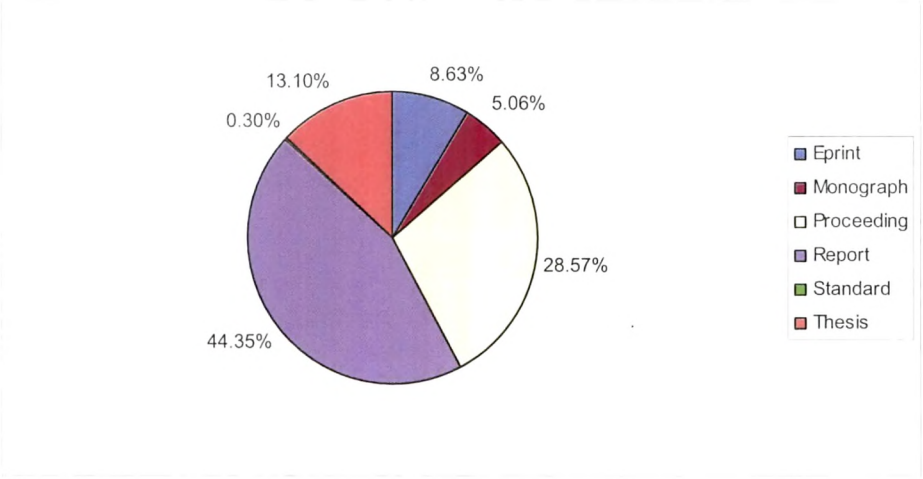
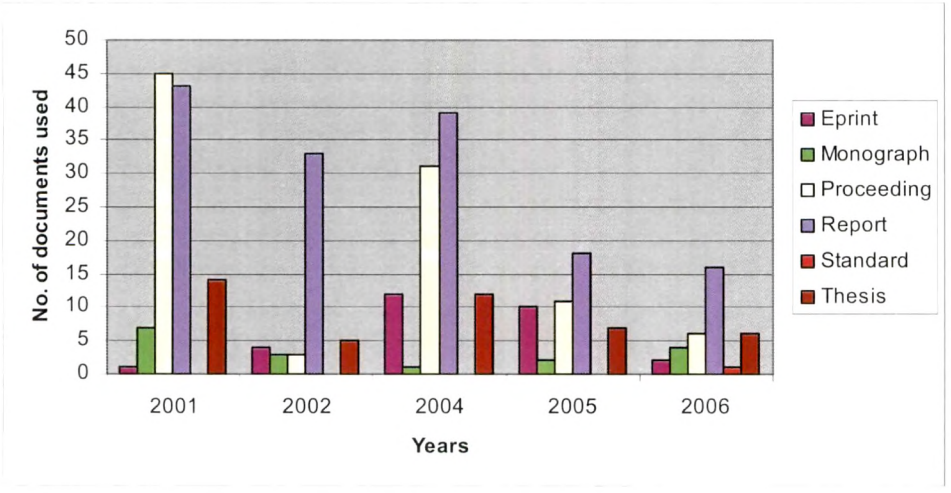


Fig 3.9a : Year wise pattern of use of 'Other Documents' from 2001-2006



Thus during the ejournal period 'Reports' are cited the most (44.35%) followed by 'Conference Proceedings' (28.57%), probably because of the availability of many of the government reports in public domain and easy accessibility through the world wide web. The preference of Monographs has increased during this time slab while proportion of theses has decreased. There is one more category which has been used during this time period – Standard.

Division wise break up of citation data

To get meaningful information about the usage of the library collection by the students, the researcher thought it appropriate to classify the collected citation data according to the subject divisions at PRL. Here, it needs to be mentioned that Solar Physics remains under the umbrella of Astronomy and PSDN (Planetary Science Division) remains under GSDN. Total 68 theses were submitted. Bibliographies of these 68 theses yielded 10,864 citations.

Division wise break of these 10,864 citations is given below. The data presented shows that Space Sciences students have given maximum number of citations (185/thesis) followed by Geosciences (171/thesis).

Table 3.10 : Division wise break up of theses submitted during 1997-2006

Division	No. of theses	Total citations	Citations/thesis
AAD	10	1484	148
GSDN	24	4095	171
SPA-SC	13	2403	185
THE-PH	21	2882	137
Total	68	10864	160

It seems number of citations appended at the end of research article or a thesis is subject specific. Astronomy and Theoretical Physics students tend to cite less number of sources.

According to Edwards (1999) "citation analysis can also be used to determine a core list of journals critical to local users and representative of the research needs of the collection." The citation data of the theses' sample was used to know the core journals for each division. Top 10 most cited journals form the Core Journal Group. Table 3.11 below gives the overall picture of total number of citations, journal citations and core journal group citations during 1997-2006 for four major divisions – Astronomy (AAD), Theoretical Physics (THE-PH), Geosciences (GSDN) and Space Science (SPA-SC) divisions. Astronomy Core Journal Group accounts for 85.71% of the journal citations, THE-PH Core Journals satisfy 64.61% of journal citations, the Core Group for GSDN accounts for 50.29% and Core Group for SPA-SC make up 69.75% of journal citations.

Table 3.11 : Division wise break up of number of Core Journal Group citations

Division	Total No. of citations	No. of Journal citations	No. of Core Journal citations	%
AAD	1484	1253	1074	85.71
THE-PH	2882	2492	1610	64.61
GSDN	4095	3253	1636	50.29
SPA-SC	2403	2132	1487	69.75
Total	10864	9130	5807	63.60

The above finding confirms Edward's study that a set of core journals (10 most cited journals) account for more than 50% of the total number of journal citations used.

However there is a considerable variation amongst the four subject areas. In Astronomy, the Core Group account for 85.71% of total number of journals used; in Theoretical Physics, Core Group of journals make up for 64.61% of the total number of journals used, in Geosciences, the Core Group accounts for 50.29% of total number of journals used, in Space & Atmospheric Sciences, Core Group makes up for 69.75% of total number of journals used. The lower core group percentage in Geosciences (50.29%) of the total journal citations might indicate the existence and availability of more number of important journals in that subject. Thus overall 63.60 % of journal citations come from top 40 journals (10 in each subject division). This study also confirms the Bradford's law that a set of core journals in a subject field satisfy more than 50% of the total number of journal citations.

Most used Journals

One of the objectives of the present study was to determine the usage of the library collection by the doctoral students of PRL. This was done by studying the citations listed by the students in the bibliographies at the end of the theses submitted.

The Table 3.12 below gives the 10 most used journals in Astronomy (including Solar Physics). Important thing to note is that no Indian journal is present in the core group of journals cited by students in Astronomy division during 1997-2006. Out of a total of 1253 journal references cited, Astrophysical Journal is cited the maximum number of times (321) followed by Astronomy & Astrophysics (209) and Astronomical Journal (127). It is interesting to note that these three titles put together satisfy more than 50% of the1253 journal citations of Astronomy division.

Table 3.12 : Top 10 cited journals in Astronomy

TOP 10 JOURNALS CITED IN ASTRONOMY	1074
Astrophysical Journal	321
Astronomy & Astrophysics	209
Astronomical Journal	127
Solar Physics	121
Monthly Notices of the Royal Astronomical Society	119
Astrophysical Journal Suppl.	64
Pub. of the Astron. Soc. of the Pacific	45
Astronomy & Astrophysics Suppl.	38
Pub. of the Astron. Soc. of Japan	15
Space Science Reviews	15

Table 3.13 gives the list of journals most cited in Geosciences. Out of 3,253 journal citations Geochimica Et Cosmochimica Acta was cited 401 times followed by Journal of Geophysical Research (249) and Earth and Planetary Science Letters (239).

Table 3.13 : Top 10 cited journals in Geosciences

TOP 10 CITED JOURNALS IN GEOSCIENCSES	1636
Geochimica Et Cosmochimica Acta	401
Journal of Geophysical Research	249
Earth and Planetary Science Letters	239
Nature	204
Science	163
Chemical Geology	120
Deep Sea Research	79
Geophysical Research Letters	73
Journal of Geological Society of India	55
Current Science	53

Table 3.14 gives the list of core journals most cited in Space Sciences. Out of 2132 journal citations, 1487 are core journal group citations. Journal of Geophysical Research gets the maximum number of citations (746) followed by Journal of Atmospheric & Terrestrial Physics (172) and Geophysical Research Letters (152). Here too, all the three titles put together account for more than 50% of the 2132 journal citations of Space sciences. In this subject too, not a single Indian journal is in the top 10 rank.

Table 3.14 : Top 10 cited journals in Space Science

TOP 10 CITED JOURNALS IN SPACE SCIENCE	1487
Journal of Geophysical Research	746
Journal of Atmospheric & Terrestrial Physics	172
Geophysical Research Letters	152
Atmospheric Environment	96
Planetary & Space Science	85
Nature	59
Science	52
Applied Optics	50
Journal of Chemical Physics	38
Annales Geophysicae	37

Table 3.15 shows the data for Theoretical Physics. It reveals that Physical Review Letters got the maximum number of citations (598) followed by Physical Review A (527) and Optics Communication (77). Total number of journal citations in Theoretical Physics was 2,492 and citations from core journal group were 1610. The above mentioned 3 titles account for about 50% of total journal citations of 2,492.

Table 3.15 : Top 10 cited journals in Theoretical Physics

TOP 10 CITED JOURNALS IN THEORETICAL PHYSICS	1610
Physical Review Letters	598
Physical Review A	527
Optics Communication	77
Nature	76
Physical Review E	68
Physical Review D	62
Physics Letters B	59
Physical Review	54
Optics Letters	48
Physics Report	41

The researcher also identified most used non-subscribed journal titles in each division. These are - *Information Bulletin on Variable Stars* and *Astrophysics & Space Science* for Astronomy division, *Journal of Hydrology* and *Limnology & Oceanography* for Geosciences division, *Canadian Journal of Physics* and *Chemical Physics Letters* for Space Science division and *Optics Communication* and *Annals of Physics* for Theoretical Physics.

On the other hand journals which are subscribed by the institute but have been cited only once or twice in the 10 year study period were also identified from the data collected. These are *New Astronomy, New Astronomy Reviews, Physics World* and *Radiation Measurement.* These journals may be candidates for deletion in the coming years. Thus both kinds of information used in tandem may help in subscription decisions of the institute.

Hence it can be clearly iterated that such studies are useful for identifying the gaps in library collection and subsequently addressing these issues appropriately.

PRL citations

Another objective of the study was to find the extent to which PRL research was cited by the doctoral students. Out of 10,864 citations 760 (7%) are PRL citations. It was also observed that most of the cited works were their own or their thesis supervisor's. Table 3.12 gives the division wise break up of the 760 PRL citations.

Table 3.16 : Division wise break up of PRL citations

Division	Total citations	PRL citations	%
AAD	1484	78	5.26
GSDN	4095	292	7.13
SPA-SC	2403	221	9.20
THE-PH	2882	169	5.86
Total	10864	760	7.00

The major findings of this citation analysis of theses can be summarized as :

- Average number of references per thesis has increased from 147 in pre- e-journal period to 170 in e-journal period.
- The preference for electronic resources from 1997 through 2006 confirms the findings of earlier studies. By 2006 use of electronic resources had increased so much that print and electronic resources cited, seemed almost equal.

- Journals comprise of major part of the documents cited, followed by Books and Other Documents. From 1997 through 2006, the use of the non-subscribed journals is on the rise. In 'Other documents' category, most used documents are the *Reports* followed by *Proceedings*.
- Core Journal Group (top 10 used journals) in each subject division satisfies more than 50% of the reference needs of the doctoral students at PRL. No Indian journal appears in the Core Journal Group in Astronomy, Theoretical Physics and Space Science divisions. Only in Geosciences division two Indian journals are amongst the top 10 most cited journals.
- Most used non-subscribed journal titles in each division were identified. These are - *Information Bulletin on Variable Stars* and *Astrophysics & Space Science* for Astronomy division, *Journal of Hydrology* and *Limnology & Oceanography* for Geosciences division, *Canadian Journal of Physics* and *Chemical Physics Letters* for Space Science division and *Optics Communication* and *Annals of Physics* for Theoretical Physics.
- On the other hand, the researcher also identified those journals which are subscribed by the institute but have been cited only once or twice in the 10 year study period. These are *New Astronomy, New Astronomy Reviews, Physics World* and *Radiation Measurement*
- PRL work is cited only 7% of the total citations by the doctoral students. It was also found that in Space Science Division and Geosciences Division, PRL research is cited more than Astronomy and Theoretical Division.

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