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Master's and Doctoral Thesis Citations: Analysis and Trends of a Longitudinal Study

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Abstract
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Disciplines
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Master’s and Doctoral Thesis Citations:

Analysis and Trends of a Longitudinal Study

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Analysis and Trends of a Longitudinal Study

Abstract

This article reports the results of a longitudinal study of over 9100 citations from 629 master’s and doctoral theses written between 1973 and 1992 at a large mid-western land-grant university. The results of this study suggest that graduate students writing theses favor current research regardless of disciplinary affiliation. The length of theses increased over time and the number of citations in thesis bibliographies varied by discipline. Implications of the results for collection development and scholarship as well as areas for future research are discussed.
Introduction

Citation analysis employs bibliographic data from journal articles, monographs, published bibliographies, and electronic indexes to explain trends in library use. A considerable body of literature exists which uses citation analysis methods as the basis of collection management decisions involving monographs and serials. Research using citations from graduate theses tends to focus on collection management or evaluation issues and almost exclusively uses graduate citations to examine collection patterns at a particular institution.

Another important element in analyzing citation patterns is the insights gained about the social context in which knowledge is created. The operative question is: do researchers use literature differently based on their discipline? Hargens’ article about reference networks identifies two major scholarly structures, one in which “scholars focus on recently published research while tending to ignore foundational work,” the other in which “scholars focus on early work while tending to ignore recent publications.” He reports that the natural sciences tend to fall into the former category, while the humanities and social sciences fall into the latter.

Using citation data from a group of theses it is possible to draw some conclusions about scholarly communication at the master’s and doctoral levels. This paper analyses a sample of citations from 629 master’s and doctoral theses written at Iowa State University (ISU) in Ames, Iowa between 1973 and 1992. The results show distinct trends in graduate students’ citation patterns. After a literature review and discussion of the methodology used to select and gather the data, this paper considers the following questions:
1) What are the demographic characteristics of the data?

2) What are the trends between selected data elements such as citation age in broad disciplinary categories?

3) What are the differences between master’s and doctoral theses?

4) What longitudinal trends are present for citation age, total number of citations, length of thesis, library holdings, and the serial/monograph proportion?

5) What insights about the social structure of knowledge are gained by studying graduate citation patterns?

6) What are the implications of this research and what future study is needed?

Literature Review

The role and purpose of graduate theses

A thesis shows proof of both an original contribution to knowledge and substantial subject knowledge in a discipline. While a thesis provides evidence of significant scholarly achievement, the mechanics involved in producing the thesis are part of the socialization process for young scholars. Davinson states: the doctoral thesis has come to be thought of in some countries and institutions as simply the demonstration that a certain amount of research methodology has been transmitted and received, with much less emphasis than used to be the case upon the nature and significance of the topic explored.²

The thesis is the culmination of a rigorous formal educational process. It also validates a graduate student’s entry into the academic profession. The doctoral thesis sets the stage for future scholarly efforts, though some thesis work is more substantive. For example, Nicholas invented the encoding process eventually used to speed transmission times in
fax machines as part of his graduate thesis.\textsuperscript{3} The thesis resulted in two patents and the technology used to develop a faster, less expensive fax machine. Rogers mentions the increase in transmission speed as a major reason for the adoption of fax technology in the early 1980s, validating the innovation introduced by Nicholas’ doctoral thesis.\textsuperscript{4} Generally, however, the intellectual contributions represented in theses tend to be more incremental than transformational.

Handbooks on thesis preparation demonstrate that thesis formats are an institutionalized part of graduate education.\textsuperscript{5} While the format of the thesis may be standardized, the experimental methods, citation styles, methods of documentation, and attribution reflect the socialization process within individual disciplines. Becher examined twelve different disciplines and noted that separate cultures and norms exist: “the ways in which particular groups of academics organize their professional lives are intimately related to the intellectual tasks on which they are engaged.”\textsuperscript{6} He notes that there are two types of tacit knowledge that graduate students need in order to successfully complete their studies: subject knowledge in their disciplinary area and knowledge of normative behavior for their discipline. Knowledge of the culture of the disciplinary area, the behavioral and political process in which education takes place, is as important as substantive knowledge of an academic field. The socialization of academics begins as early as undergraduate studies, and continues through graduate school and on into academe. The goal of the educational process is to instill both substantial subject knowledge and the cultural norms of the discipline that will guide graduate students in their development as professionals. Both Rossides and Larson discuss a spectrum of academic disciplines (Sociology, Economics, History, Natural Sciences, Mathematics,
Literary Studies) and applied professions (Medicine, Law, Engineering) focusing on their social functions and the historical context in which they developed. The historical context provides the framework in which to view development of both the subject knowledge and cultural norms for a discipline.

**Availability of theses for research**

The thesis represents the end of an extensive education process that results in new contributions to knowledge. How and where that new knowledge is disseminated is another question. Repp and Glaviano’s exploration of the ways scholars use dissertations, points out that services such as *Dissertation Abstracts International (DAI)* and University Microforms, now known as UMI, make the acquisition of doctoral theses by scholars relatively easy, especially for those published in the United States. Until recently, research using theses as a data source has generally been confined to studying theses from a single institution because of the ways that theses were produced and distributed. Electronic initiatives, such as the Networked Digital Library of Theses and Dissertations, now provide online access to theses and dissertations from around the world.

**Citation analysis and the study of graduate theses**

Citation analysis enjoys a long history as a methodological tradition in library and information science. Reviews of citation analysis methodology by Osareh, McCain, and McRoberts and McRoberts elucidate the major methodological approaches. Citation analysis has been used as a collection evaluation tool in the humanities by Broadus, in the social sciences by Fitzgibbons, and in science and technology by Subramanyam, though these are representative examples of a large body of work. Nisonger’s book includes
several chapters on both the methodology and application of citation analysis as a collection evaluation method.\textsuperscript{18}

The data used for many citation analysis studies is the scholarly output of faculty members in a discipline, usually drawn from bibliographies appearing in journals or monographs. Relatively few studies use citation analysis to examine undergraduate and graduate papers. Recent citation studies of undergraduate papers have focused on the use of web resources and their impact on citation behavior.\textsuperscript{19-22} Fewer still use citation analysis as a means of examining the intellectual content of graduate work. Magrill and St. Clair examined citations from undergraduate papers to compare the literature use by undergraduates in different disciplines.\textsuperscript{23} In a subsequent article, they looked at the age and format of citations in undergraduate papers, and, after an exhaustive literature review conclude that “very little has been published regarding the application of citation analysis to any group other than scholars.”\textsuperscript{24} Citation analysis research using graduate theses has been more prevalent in the past ten years, although there are earlier examples. Table 1 summarizes recent research using theses as a data source for citation analysis.

[Insert Table 1, File: PortTab1.doc]

The most common thread in the research listed in Table 1 is the use of graduate citation data as a collection management tool, answering the question: What materials do graduate students use and how does this use impact the collection management efforts of the library? Johnson, McCain and Bobick, and Zipp focus their evaluations on departmental libraries, with graduate citations included as part of larger data sets.\textsuperscript{32, 39, 50} Buttlar, Slutz, and Thompson examine the demographic characteristics of the citations in
a thesis, focusing on citation format, gender of author, and methodological approach.\textsuperscript{26, 43, 46} Articles by Marinko, Peritz and Sor, and Walcott are notable because their data sets included theses from multiple institutions.\textsuperscript{38, 40, 48} The subject focus of existing research is multidisciplinary, suggesting that the analysis of graduate citations is useful in a broad range of disciplines.

**The social context of knowledge**

Citation analysis is used extensively as a collection management tool, but it also is used to explore questions related to the sociology of knowledge. What are the disciplinary boundaries of a field? What relationships exist between researchers in a given field? The most often used bibliometric method for exploring these relationships is author co-citation analysis (ACA). ACA may be used to determine which scholars contribute to a discipline, and which areas of study make up an interdisciplinary area. Borgmann provides a comprehensive volume on scholarly communication and bibliometrics, including a number of chapters on ACA.\textsuperscript{51} Kärkii’s study of scholarly communication research explores the intersection of information science and the sociology of science, concluding that information scientists and sociologists stay within their own fields when researching scholarly communication.\textsuperscript{52} More recent articles by White and McCain, and Ding, Chowdhury and Foo map the intellectual boundaries of information science.\textsuperscript{53, 54}

Social network analysis (SNA) is a subspecialty within sociology concerned with the structural analysis of social interaction. SNA analyses interactions between individuals using data from questionnaires, interviews, observation, archival records, and experimental techniques. Descriptions of the methodologies used in social network
analysis can be found in books by Wassermann and Faust, and Scott. Hummon and Carley use bibliographic citations and the SNA technique of main path analysis to explore the connections between researchers published in the journal *Social Networks*.

**Methodology**

The theses used in this study are from Iowa State University, which since 1973 has shelved its master’s and doctoral theses in a common location with a local call number, arranged by year, then by author name, regardless of the degree granted. This centralized shelving location facilitated the identification and selection of theses.

The total number of theses selected for the sample, 629, comprised 5% of all theses published at Iowa State University from 1973 through 1992. The title pages and bibliographies for the selected theses were photocopied, demographic data about each thesis was collected (department, major, publication date, number of pages, and total number of citations), and each was assigned a unique identification number to identify both the thesis and its corresponding citations. Theses were assigned to one of five broad disciplinary categories: Arts and Humanities, Biological Sciences (including Agriculture and Veterinary Medicine), Engineering, Physical Sciences, and Social Sciences, based on the author’s self-identified department of study or major.

Once data about each thesis was recorded, the task of identifying and recording information about the individual citations began. Every fifth citation was selected, rounded down to the nearest five citations. For example, a thesis containing four citations would have no citations recorded for it, while a thesis with forty-nine citations would have nine citations recorded. A total of 46,742 individual citations are included in this group of theses, from which 9,102 citations, or approximately 20% were selected for
detailed analysis. One thesis, selected for the project, was not included in the sample because its extreme number of citations skewed results for the population. The data elements collected for both the theses and the individual citations are described in Table 2.

[Insert Table 2: Data elements for the thesis project]

Results

Demographic Characteristics

Descriptive statistics for the theses provide a starting point for understanding the trends in the data. The theses fall into broad disciplinary areas as follows: 4.9% Arts and Humanities (n=31), 36.9% Social Sciences (n=232), 27.0% Biological Sciences (n=170), 10.5% Physical Sciences (n=66) and 20.7% Engineering (n=130). Theses from 57 academic departments are represented. The sample includes 261 (41.5%) doctoral and 368 (58.5%) master’s theses.

[Insert Table 3: Selected Citation Indicators]

Table 3 shows the frequency distributions for citations by format and library ownership. Journals and monographs account for 63.6% (n=5790) and 23.7% (n=2153) of the total citations respectively, with no other format representing more than 4% of the total citations. No citations to Web materials were identified during the data gathering and analysis, which is not surprising given the age of this data set. The Library owns just over 85% of the materials represented by the citations (n=7746).
Figure 1 shows the frequency distribution of citation ages. The mean age of citations is 12 years, with a median of 8 years. The range of citation ages, however, is 337 years. Half of the citations are 8 years old or less and 90% of the citations are 26 years old or less. Demographic information about the theses in this data sample provides a baseline of information from which to proceed; the analysis of specific variables and longitudinal trends will demonstrate more interesting insights.

**Trends by Disciplinary Category**

Using the department names collected from the thesis title pages, theses were grouped into one of five broad disciplinary categories. These categories are by definition multidisciplinary areas; a list of the departments placed in each category is included as Appendix A. The subcategorizing of science into three discrete areas reflects the disciplinary focus of ISU as an institution, which has significant program strengths in biological sciences and engineering. The three science fields together represent more than 60% of the total theses in the sample; combining them into one category may obscure patterns of scholarship that are unique to particular scientific disciplines. There are some important findings when looking at citations by subject categories.

The age distribution of citations by discipline is similar to the age distribution shown in Figure 1. The mean citation age for the population is 12.3 years, and the mean citation ages for the disciplinary groups vary from a high of 18.1 years for Arts and Humanities citations to a low of 10.9 years for Engineering citations. Half of the citations in Social Sciences, Physical Sciences, and Engineering are 7 years old or less.
In the Arts and Humanities and Biological Sciences half the citations are 10 years old or less. In all disciplines except one, 90% of the citations are 29 years old or less. Arts and Humanities is the exception, where 90% of the citations are 49 years old or less. The most likely explanation for this is the presence of history theses in this disciplinary group.

[Insert Figure 2: Citation Format by Discipline]

Turning attention to the format of materials in Figure 2, journals and monographs comprise more than 87% of the overall citations and more than 80% of the citations for each subject category, though the proportion of monographs and serials varies by discipline. Biological Sciences uses the largest proportion of journals (78.6%), while Arts and Humanities use the smallest proportion (29.0%). The science disciplines use more journal literature than either the Arts and Humanities or the Social Sciences.

**Trends by Degree**

Citation trends by degree demonstrate that students working on a doctoral thesis cite more and write more than their counterparts completing a master’s thesis. The box plots in Figure 3 show the distributions of the number of citations and number of pages by type of degree.

[Insert Figure 3: Dist of Citations by Degree]

Doctoral candidates’ theses contain an average of 43.6 more citations and 55 more pages than their counterparts writing a master’s thesis. On a per page basis, doctoral theses contain 62.4 citations per hundred pages, while master’s theses contain 54.4 citations per hundred pages.

**Longitudinal Trends**
To evaluate longitudinal trends, the data was divided into four quartiles, each containing a five-year block of data. The time periods represented by the quartiles are 1973-1977, 1978-1982, 1983-1987, and 1988-1992. The five-year divisions provide enough citations for each subject code so that meaningful observations can be made about the data.

[Insert Figure 4: Mean citation age by quartile]

The mean citation age by quartiles for each subject code is shown in Figure 4. The differences between the subject codes show some interesting trends. The Social Sciences and Engineering groups show a decrease in average citation age over time, while the Physical Sciences citations increase slightly in age and the Biological Sciences citations remain essentially stable. Arts and Humanities shows considerable variation, due in part to the small number of theses from which the citations are drawn.

[Insert Figure 5: Journal and monograph proportion by quartile]

The proportion of journal and monographic literature over time is shown in Figure 5. Biological and Physical Sciences maintain journal usage of over 80% over time. Engineering shows a variation of between 65% and 75% journal literature. Social Sciences show a steady 45% monograph, 55% journal proportion over time, while the Arts and Humanities see an increase in journal use over time from less than 20% in Quartile 1 (1973-1977) to over 50% in Quartile 4 (1988-1992).

[Insert Figure 6: Titles owned by quartile]

One measure of an institution’s ability to support graduate research is its library holdings. Figure 6 shows the trends in the holdings of monographs and journals by subject over time. The sciences have consistently high rates of library ownership, while
the social sciences remain relatively constant over time and the humanities show a large increase. This is a reflection of the disciplinary bias of the institution. However, the increase in the percentage of titles in the humanities demonstrates that institutional support for humanities disciplinary areas increased between 1973 and 1992.

[Insert Table 4: Citations per hundred pages]

Tables 4 and 5 show the number of citations per hundred pages and the number of pages per thesis over time. The number of citations per hundred pages shows an increase over time for doctoral theses in the Biological and Physical Sciences and a decrease in citations for Physical Sciences master’s theses. Both levels of Engineering theses and Biological Sciences master’s theses remain steady over time. The trends in the number of pages per thesis in Figure 5 show a consistent difference between doctoral and master’s theses, with doctoral theses being about fifty percent longer than master’s theses.

[Insert Figure 5: Pages per thesis]

Discussion

Trends by Discipline

In an earlier section, it was mentioned that for all citations, half are less than 10 years old. Overall, 70% of the citations are less than 13 years old. This would indicate that students working on a thesis tend to cite recent works. There are, of course, disciplinary variations. Arts and Humanities and Biological Sciences citations both cite older works, with 19.5% and 13.5% of their citations respectively older than 26 years, while less than 10% of the citations of any other subject areas are more than 26 years old.
Turning attention to the format of materials in Figure 2, journals and monographs comprise more than 87% of the overall citations and more than 80% of the citations for each subject category. Engineering uses about 59% journals, while Biological and Physical Sciences both use more than 70% journals. A factor that may account for the lower journal percentage in engineering may be that conference proceedings, which are sometimes classified as journals, are categorized in this study as a separate category. Arts and Humanities theses predominantly cite monographs (66%), while the Social Sciences are the largest users of other theses (50%).

**Trends by Degree**

Interpreting the results from this data leads in several directions. First, it is evident that significant differences exist between master’s and doctoral theses. This may be an indication of differing expectations for master’s and doctoral students, as described in the existing graduate education literature.

Explanations for citation age differences are more difficult to discern. One explanation for the age difference may be that writers of master’s theses cite more foundational literature than their doctoral counterparts in order to provide evidence of the depth of their subject knowledge. The slight age difference may also be the result of the very specific, focused topics chosen for graduate theses.

These results are not surprising given the expectation that the doctoral thesis is an original contribution to knowledge. This may partially explain the differences in citation and page amounts, but this is a generalization about scholarship rather than an empirically proven assertion. The thesis excluded from the sample was a master’s thesis containing 1199 citations, many of them references to abstracts. It is important to
remember that citations are an indication of the items listed in the references, not necessarily a measurement of use.

There are also distinct differences between subject areas. These differences also support existing theories about the social structure of broad subject areas in terms of citation trends. The lack of a clear difference in the citation ages between the different subject groupings does not support Hargens’ conclusions about the relationship between foundational and current research. One reason for this may be that Hargens concentrated his research on specific subject areas, while this study looked at groups of disciplines. This study provides evidence that the content of citations in graduate theses is more complex than previously thought and merits more research.

**Longitudinal trends**

Citation analyses of different subject areas mentioned in the literature review have established that, for example, natural sciences cite more journal literature, while social sciences and the arts and humanities cite more monographic literature. In part this is the result of publishing patterns in different disciplines, but it is also a reflection of the communication networks and social norms in which disciplines operate. Clemens et al. discuss the publishing patterns in Sociology, which are split between monographs and journal literature, due to a complex set of variables that includes the institutional affiliation of the author, the school that the author attended, gender, and the branch of Sociology in which authors conduct their research.

The data confirm that the trends in the citation of journals and monographs are consistent in the sciences over time (Figure 5). There is a large change in the amount of journal literature cited in the Arts and Humanities, from approximately 20% in the first
three quartiles to over 50% in the last quartile. This change in the journal proportion for Arts and Humanities may be attributed to a number of factors. There are only thirty-one theses in this disciplinary area, partially a reflection of historical and curricular emphasis on science and technology at ISU. The resulting small number of citations (n=200) in this group may skew the results divided among four quartiles. Another reason may be a growth in the volume of journal literature published in the humanities between 1973 and 1992. Finally, the individual subjects for the theses in each quartile have an impact on amount of journal literature cited.

Doctoral theses also show an increase in the number of pages over time, while the number of pages in master’s theses increase in the Arts and Humanities and are steady in other subject areas. The increase in the number of pages per thesis may reflect a general increase in scholarly activity, particularly in subject areas that also saw an increase in citations over time. The decrease in the number of pages for social sciences master’s theses may be the result of a number of factors, including changes in programmatic expectations, and a different mix of departments contributing theses.

Longitudinal trends show that the number of pages per thesis has increased over time, and there is some evidence to suggest that the number of citations is also increasing. This study provides evidence supporting the assertion that the hard sciences cite more journal literature, and that the proportion of journal citations in the sciences has remained steady over time.

**Conclusions**

The evidence from this study suggests that graduate students writing theses favor current research. The average age of citations in the sample decreases for most
disciplinary groups, indicating that current research is being used when writing theses. Doctoral theses are consistently longer than the master’s theses over time, while the number of citations in theses varies by discipline. One logical extension of this study would be an examination of citation trends for individual disciplines.

This study confirms results from other research showing that the use of literature in graduate theses varies by subject. A distinguishing feature of this research is that it looks at disciplinary groups rather than individual academic subjects. It adds more credence to the generally accepted supposition that scientific disciplines cite more journal literature than disciplines in the social sciences or arts and humanities.

This research has important collection development implications. The main conclusion, that graduate students are citing recent literature in their theses is particularly noteworthy. Is this pattern of using current citations particular to thesis writers or is it indicative of a trend across scholarship in general? If further research supports the conclusion that the age of citations is decreasing regardless of the type of scholarship, fundamental collection development issues may need to be reevaluated. Can collection development policies be formulated that take into account how subject literatures are being cited by researchers? Do RLG Conspectus collection categories need to be revised to control for variations in literature use by different disciplines?

This study also poses questions for scholars researching the nature of scholarship. While these findings do not support Hargens’ assertion that there are two types of reference networks, there are certainly other social (and bibliometric) phenomena happening. Further research is needed to uncover and communicate them. Have there been changes in the social structure in graduate education? If so, do those changes in any
way explain changes in citation behavior? What relationship is there between a graduate advisor’s educational background and their expectations for current graduate students? What changes in research methodology may contribute to citation behavior? What impact do citations to Web resources have on citation trends?

The sampling methodology used for this study is generalizable to other types of research involving theses. The methodology can easily be adapted to projects at other institutions or to research using electronic theses available on the Internet.

One of the limitations of this research is the grouping of graduate theses into broad disciplinary areas. Ambiguity is introduced into the analysis when possibly disparate disciplines are lumped together in the same broad disciplinary category. Further research needs to be done to determine whether the results of this study can be confirmed for theses from individual subject areas. Another possibility for research is the analysis of citations in recent theses to determine whether citations to electronic information sources are lessening reliance on traditional printed materials.

Finally, further research needs to be done to examine intellectual content of graduate thesis citations. One data element collected for this study but not used is the ISSN (International Standard Serial Number) for each journal citation. Cross tabulations of ISSN numbers and publication date with specific subject codes or disciplines will provide more detailed information about journal use in different disciplines.

**Acknowledgments:** This research was supported in part by a grant from the Iowa State University Library Travel and Research Committee.
Appendix A: Broad Disciplinary Areas and Corresponding Departments

**Art and Humanities**
Art and Design
English
History
Landscape Architecture

**Biological Sciences**
Agronomy
Animal Ecology
Animal Science
Bacteriology
Biochemistry and Biophysics
Botany
Entomology
Food Science and Human Nutrition
Forestry
Genetics
Horticulture
Microbiology, Immunology, and Preventive Medicine
Plant Pathology
Veterinary Anatomy
Veterinary Microbiology and Preventive Medicine
Veterinary Pathology
Veterinary Physiology and Pharmacology
Zoology

**Engineering**
Aerospace Engineering and Engineering Mechanics
Agricultural and Biosystems Engineering
Biomedical Engineering
Chemical Engineering and Nuclear Engineering
Civil Engineering
Electrical Engineering and Computer Engineering
Engineering Science and Mechanics
Industrial and Manufacturing Systems Engineering
Industrial Engineering
Materials Science and Engineering
Mechanical Engineering
Physical Sciences
Chemistry
Earth Sciences
Geological and Atmospheric Sciences
Physics and Astronomy

Social Sciences
Agricultural Education and Studies
Community and Regional Planning
Computer Science
Economics
FCS Education and Studies
Hotel, Restaurant and Institution Management
Human Development and Family Studies
Industrial Administration
Industrial Education and Technology
Industrial Relations
Journalism and Mass Communication
Liberal Arts and Sciences
Mathematics
Physical Education and Leisure Studies
Political Science
Professional Studies in Education
Psychology
Public Administration
Sociology and Anthropology
Statistics
Textiles and Clothing
References


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University, 2000).


<table>
<thead>
<tr>
<th>Author</th>
<th>Date</th>
<th>Subject</th>
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<td>1994</td>
<td>Political Science</td>
<td>Serials Evaluation</td>
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<td>Buttlar</td>
<td>1999</td>
<td>Information Science</td>
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Selected Citation Indicators

3-1: Citation frequencies by Format

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Figure 1: Age Distribution of Citations
Figure 2: Citation Format by Discipline

- **Arts & Humanities**
  - Other: 100
  - Conf. Proceed.: 50
  - Thesis: 200
  - Monograph: 150
  - Journal: 300

- **Biological Sciences**
  - Other: 2500
  - Conf. Proceed.: 1000
  - Thesis: 1500
  - Monograph: 500
  - Journal: 2000

- **Engineering**
  - Other: 200
  - Conf. Proceed.: 100
  - Thesis: 50
  - Monograph: 150
  - Journal: 100

**Number of Citations**
Figure 3: Distribution of Citations and Pages per Thesis by Degree
Figure 4: Mean Citation Age by Quartile
Figure 6: Titles Owned by Quartile

- Arts & Humanities
- Social Sciences
- Biological Sciences
- Physical Sciences
- Engineering

Percentage of Titles Owned

Quartiles

1973-1977
1978-1982
1983-1987
1988-1992