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A BIBLIOMETRIC ANALYSIS OF THE DESIGN 2012 CONFERENCE

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ABSTRACT

Bibliometric analyses play an important role in reflecting on a research field and identifying areas of strength and weakness. This paper builds on recent reflective efforts within the community by presenting a bibliometric analysis of the DESIGN 2012 conference. Over 2700 citations were identified, classified and grouped in order to describe citation trends by field, type of work and distribution. Based on this multifaceted analysis three key conclusions are drawn. First, the uptake and impact of work from fields other than design is unexpectedly low given the research themes within the design research community. Second, where other fields are cited there is little focus, suggesting that citation and uptake of key principals is generally ineffective and is not then subsequently incorporated into the design research corpus. Finally, we conclude that it is critical that a concerted effort be made by the community as well as individual authors to consider the wider scope of work from related fields, and that this learning is incorporated into the design research corpus in a coherent and focused manner.

Keywords: research methodology, bibliometric study, critical review

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1 INTRODUCTION

Defining and mapping the design research community has become an increasingly important theme as researchers strive to identify better and more relevant research methods, understand and bring together the wider community and implement research findings in practice (Finger and Dixon, 1989a, 1989b, Horvath, 2004). Most recently this has been highlighted by keynote addresses at two Design Society (2012) conferences – Marjanovic (2012) mapped research themes over time while McMahon (2011) analyzed the diversity of the field.

However, an important corollary to these approaches is the analysis of citations in order to critically reflect on the field, in particular the way in which work from other disciplines has been incorporated and more generally how work spreads and has impact. In this regard, Chai and Xiao (2012) used bibliometric analysis to conduct an introspective analysis of citations and co-citations within the journal *Design Studies* over the last fifteen years. This allowed them to identify core literature within the field as well as the most important design research journals and co-citation networks over time. However, a limitation of Chai and Xiao was that they did not consider the distribution of citations across other fields. They note that although *Design Studies* is consistently the most cited journal it accounts for less than 10% of the total citations, and thus conclude that journals from other fields play a key role. A further limitation is that as the work focuses on one journal it is unclear whether this represents the whole community effectively.

This paper will examine these limitations and build on Chai and Xiao's (2012) work by conducting an analysis of the most recent Design Society endorsed conference which does not have a specific focus. The paper will focus on characterizing the results in comparison to Chai and Xiao's analysis, with respect to citations in other fields and finally by reflecting on the aspirations of the Design Society and conference itself. Based on this focus, the aim of the paper is to examine the uptake and impact of work from other domains in the context of design research and identify key lessons that can be drawn from this data.

2 CITATION ANALYSIS

Citation analysis has consistently been highlighted as an important tool across fields for a number of reasons, discussed in this section.

Firstly, a key outcome of citation analysis is in improving understanding of a research field, giving insight into the different groups, important bodies and propagation of knowledge (White and McCain, 1998, Moed, 2005). In particular this can be powerful when used to identify trends or patterns over time (Greenberg, 2009). In this context citation analysis can be used to identify core groupings versus outliers, gaps in current knowledge and help researchers to more effectively target relevant information sources as well as their own citation and contribution.

Secondly, building on the improved understanding of field composition and structure over time citation analysis allows for the characterization of the influence of core works (Nerur et al., 2005). This can be used to reflect on the level of focus in the field – are citations sought on an ad-hoc basis or in a more structured and focused manner. For example, in fields where there is little emphasis on critical review, building on existing work, reanalysis or replication it might be expected that even significant works would be cited only sporadically, with authors instead searching independently for each publication with no clear body of core knowledge to build on. This can also be reflected at a source level in terms of citations directed to specific journals or conferences.

Finally, the examination of citation within a field versus citation of other fields gives a measure of the cohesiveness of a group or field (Smith, 1981). This can give a measure of how tightly interlinked a field is and allow for a reflection on the appropriateness of this level of cohesion. For example, a field with clear multi-disciplinary aspirations could be expected to be less cohesive (citing other fields more frequently) in comparison to a highly focused specialized field where only one or two other fields might constitute appropriate sources. Further, by defining the cohesiveness of a field and identifying those other fields that are frequently cited it is possible to identify and link sources of knowledge relevant to new areas of research (Nerur et al., 2005). This can be used to create citation networks where the use of complex network analysis has been highlighted as a key tool for exploring scientific collaboration (Newman, 2004, Powell et al., 2005). However, this is extremely labor and data intensive in terms of the data extraction and manipulation required.

Based on this review and the recent focus on understanding these areas within the design research community itself (either through citations (Chai and Xiao, 2012), keywords (McMahon, 2011) or topics (Marjanovic, 2012)), three key areas of interest have been identified:

- The distribution of citations with regard to specific sources and the cohesiveness of the field. In this context it is hypothesized that design research should show only limited cohesion due to the range of subjects covered whilst showing strongly focused citation of key sources relating to each area e.g. design thinking to psychology.
- The potential imbalance between design research's themes and aspirations in comparison to citation of relevant sources in fields also studying these phenomena. In this regard it is hypothesized that despite a focus on certain aspects of design, such as design thinking, there is little focused citation of fields relevant to this area, such as psychology.
- The similarity of citation trends in a conference setting in comparison to a journal. It is suggested that the citation limits imposed by conferences have a significant affect on the citation of appropriate work outside of the field and thus artificially limits the scope of conference reporting.

In order to answer these questions and give maximum benefit from this work the method builds on that used by Chai and Xiao (2012). The method and corpus are described in the next section.

3 METHOD

For this study the proceedings of the 12th International Design Conference – DESIGN 2012 were selected to form the basis for the analysis. This corpus was selected for several reasons. Firstly, the conference represents the most recent conference of the Design Society (2012) and, as such, represents the most current picture of the design research field. Secondly, the conference covers all aspects of design research from theory and methodology to systems, engineering practice and industrial design, ensuring that a representative sample is provided. This also gives a comparable scope of publication to that encountered in the Design Studies journal. Finally, a conference corpus was selected in order to complement and build on the work of Chai and Xiao (2012), providing a counter point to their journal focused work.

Using this corpus resulted in 211 papers being considered with 2796 citations in total. The method of extraction and analysis took the following steps:

1. Citations were extracted from the pdf documents (provided in the conference proceedings) automatically based on the paper structure defined in the conference template.
2. A manual check was then carried out to ensure all papers had been considered.
3. Once extracted the raw data was tabulated according to author, source, title and year. The data was then further refined to ensure that there were no duplications of sources due to formatting or spelling differences. For example, citation 'A' referring to the '12th International Design Conference' would be considered to have the same source as citation 'B' referring to 'DESIGN 2012' – the same conference. This refinement was achieved by sorting citations by source and then combining analogous sources into a single group. The same process was carried out for spelling and other formatting errors before the authors manually checked the remaining citations for repetitions.
4. Finally, all citations were defined with respect to the field from which they originated using the following tags: Engineering design and manufacturing (henceforth referred to Design), Management, Psychology, Human computer interaction (HCI), Education and Other.

With the collection and refinement complete it was possible to analyze the data with respect to the three main areas outlined in Section 2.

4 RESULTS

This section presents the main data associated with each area before these are brought together and discussed with respect to the wider design research field in Section 5.

4.1 Distribution of citations

Firstly, it is necessary to examine the distribution of the citation corpus with respect to the type of sources, their fields of origin and their relative importance within the corpus.

Figure 1 shows the distribution of citations by type. The most significant types are journals, books and conferences. In this case there were eight categories with less than 1% of the total citations (media

article, white paper, test protocol, lecture notes, report, programming code, manual and patent). As such, these are not shown in the figure.

Figure 2 then gives the breakdown of the citations by field. In this case the most significant fields, as distinct entities, were design, management and psychology. ‘Other’ has been used to note any field with less than one percent of the overall citations. The most significant fields not specifically noted here are computing and computer science as distinct from HCI, the natural sciences including the journals Nature and Science, artificial intelligence and economics and business

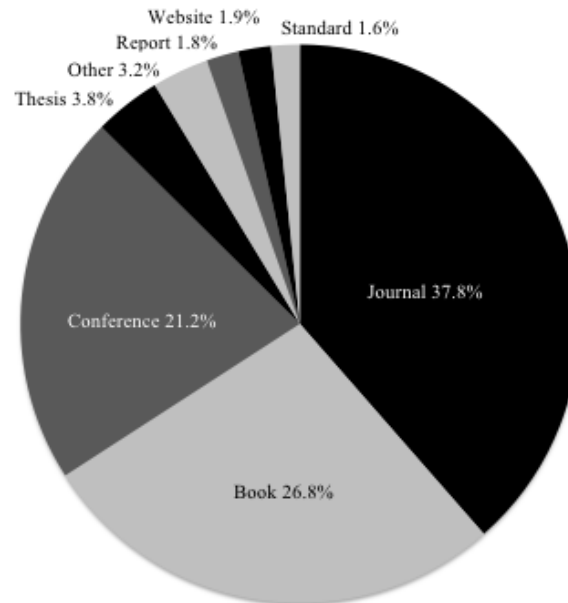


Figure 1. Distribution of citations by type

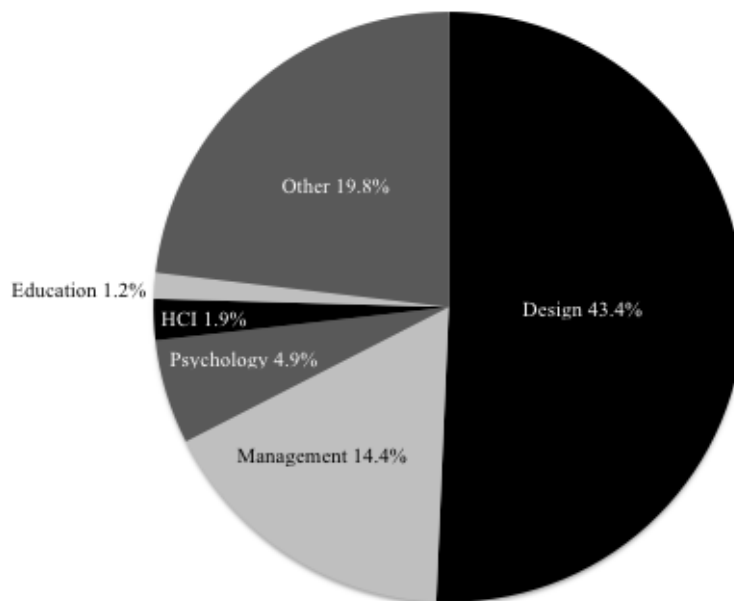


Figure 2. Distribution of citations by field

A break down of fields by type of source is also included in Table 1 – only the three main types have been considered for clarity. Table 1 also shows the total number of sources for each field.

Table 1. Distribution of citations by field for the main sources

Field	Type of source by citations						Total N ^o of sources by field
	Journal		Book		Conference		
	Total	%	Total	%	Total	%	
Design	413	14.8	407	14.6	394	14.1	399

Management	263	9.4	109	3.9	30	1.1	201
Psychology	71	2.5	49	1.8	17	0.6	81
HCI	35	1.3	6	0.2	13	0.5	42
Education	19	0.7	11	0.4	4	0.1	33
Other	255	9.1	166	5.9	133	4.8	457

In all cases Figure 3 highlights the sharp tail-of in citation count leveling out after just 20 sources. This is true overall, however, for the fields other than design there is very little curve with citations being distributed more evenly or only a slight curve with a maximum of 28 citations for a source in Management. This is shown in Figure 3 for the different fields. An inset is included in order to show the curves for education, HCI and psychology, which are not otherwise distinguishable. Source rank was determined by the number of citations received by each source from the DESIGN 2012 dataset.

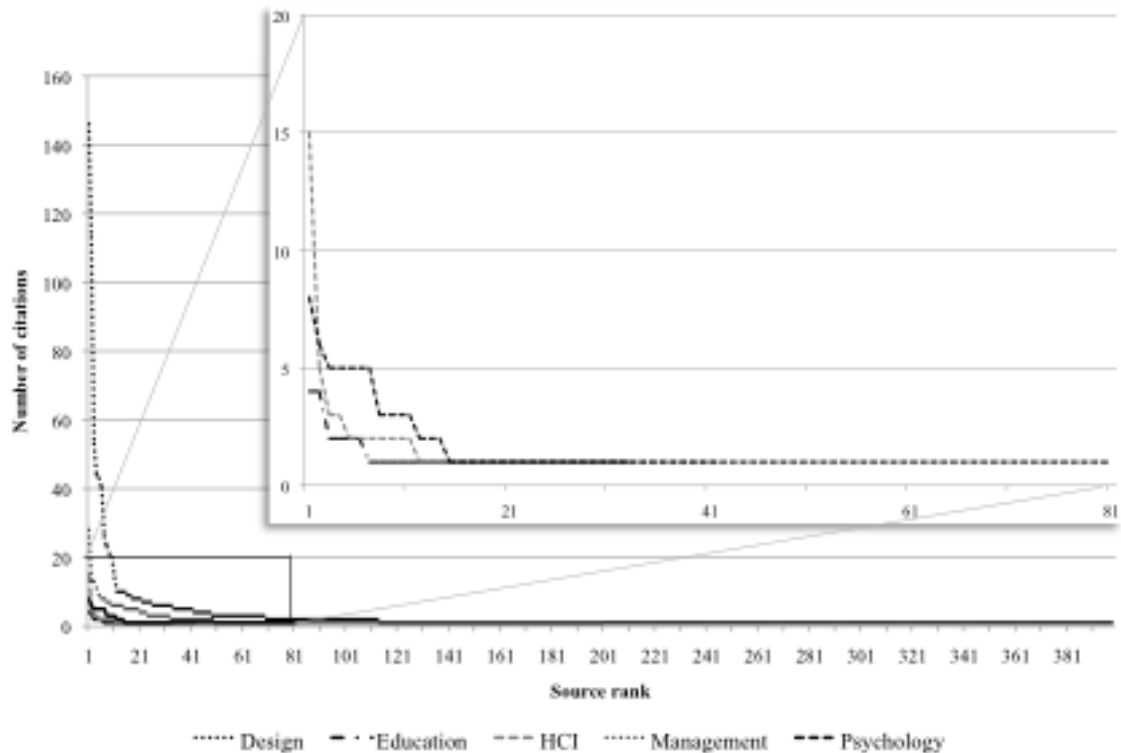


Figure 3. Tail-of in citation count for the different fields

4.2 Themes versus fields

This section examines those areas highlighted by the Design Society generally and the DESIGN 2012 conference specifically as important. These are then linked to fields outside of design that also study elements of these topics and thus are likely to be represented in the citation distribution. Table 2 outlines the main themes of the Design Society (2012) as indicated by the special interest groups (SIG's), the specific topics of focus at the DESIGN 2012 conference (2012) and the fields most likely to be associated with these topics other than design. These have been grouped where appropriate for clarity. Likely associated fields have been identified based on key common areas of interest given in the official descriptions of the SIG's (2012).

Table 2. Design Society and conference themes and their associated fields

Design Society SIG's	DESIGN 2012 conference topics (defined as proceedings chapters)	Likely associated fields
Collaborative design	Design methods	Computing, psychology, management
Eco design		
Emotional engineering		
Computational design synthesis		
Development of mechatronic products and systems		

Decision making	-	Decision making
Modeling and management of engineering processes	Design processes	Management
Risk management processes and methods in design		
Design theory	Design theory and methodology	Social science, psychology, management
Managing structural complexity	Design organization and management	Management, Complexity
Risk management processes and methods in design		
Design education	Design education	Education
-	Design information and knowledge	Knowledge and information engineering
-	Design support tools	Computer science, HCI
Human behavior in Design	Human behaviour and design	Psychology, HCI
-	Engineering design practice	-
Managing structural complexity Development of mechatronic products and systems	Systems engineering design	Systems engineering
-	Sociotechnical issues in design	Social science, HCI
-	Industrial design	Arts, Product design

4.3 Conference versus journal

As part of the comparison to the analysis carried out by Chai and Xiao (2012) the overall most cited sources have been identified. The top twenty-one sources are summarized in Table 3, which shows total number of citations, overall percentage and percentage within the sources field.

Table 3. Top twenty-one sources overall

Rank	Name	Field	Total	%	Field %
1	International Conference on Engineering Design (ICED)	Design	146	5.2	12.0
2	Design Studies	Design	113	4.0	9.3
3	International Design Conference (DESIGN)	Design	53	1.9	4.4
4	Journal of Engineering Design	Design	44	1.6	3.6
5	Research in Engineering Design	Design	43	1.5	3.5
6	American Society of Mechanical Engineers (ASME) International Design Engineering Technical Conference	Design	40	1.4	3.3
7	Journal of Product Innovation Management	Management	28	1.0	7.0
8	Journal of Cleaner Production	Inter	26	0.9	2.1
9	Engineering Design – A Systematic Approach	Design	26	0.9	4.7
10	Artificial Intelligence for Engineering Design, Analysis and Manufacturing (AI EDAM)	Design	23	0.8	1.9
11	Journal of Mechanical Design	Design	21	0.8	1.7
12	Computer Aided Design	Design	20	0.7	1.6
13	Conference on Human Factors in Computing Systems	HCI	15	0.5	27.8
14	Product Design and Development	Design	14	0.5	1.2
15	Harvard Business Review	Management	13	0.5	3.2
16	IEEE Transactions on Engineering Management	Management	13	0.5	3.2
17	Research Policy	Management	11	0.4	2.7
18	Ergonomics	Design	10	0.4	0.8
19	Tools and Methods in Competitive Engineering (TMCE)	Design	10	0.4	0.8
20	Design Process Improvement: A review of current practice	Design	10	0.4	0.8
21	DRM, a Design Research Methodology	Design	10	0.4	0.8

Finally, Table 4 highlights the most important sources identified in each of the four fields considered in addition to design. In this case only sources that stand above the tail have been included (see Figure 3). For example, the next most important source for HCI only has two citations and, as such, cannot be differentiated from the numerous other sources in this field with the same number of citations.

Table 4. Stand out sources by field

Rank	Management		Psychology	
	Name	Total	Name	Total
1	Journal of Product Innovation Management	28	Journal of Personality and Social Psychology	8
2	Harvard Business Review	13	Cognitive Psychology	5
3	IEEE Transactions on Engineering Management	13	Creative Cognition: Theory, research, and applications	5
4	Research Policy	11	Handbook of creativity	5
5	International Journal of Project Management	9	Memory and Cognition	5
Rank	HCI		Education	
	Name	Total	Name	Total
1	Conference on Human Factors in Computing Systems	15	International Journal of Engineering Education	4
2	Computers & Graphics	5	Journal of Engineering Education	4

5 DISCUSSION

As outlined in Section 2 there are three main aspects examined in this work. As such, this section splits out and discusses each aspect individually before limitations of the study are considered in Section 5.4 and overall conclusions drawn in Section 6.

5.1 Characterizing the field

The main assertion made in Section 2 with regard to the expected characterization of the design research field was that it would be relatively fragmented with only limited cohesion and significant citation of a number of important related fields as suggested by Horvath (2004) and Friedman (2003). However, by every metric considered in this paper this has not been the case.

First, within field citation accounts for over 40% of the distribution whilst management accounts for 14% and the remaining fields account for rapidly diminishing proportions of the overall total. This highlights the limited nature of citation of related fields, particularly HCI and Psychology. Second, the distribution of citations within design research emphasizes a number of key highly cited sources with a tail of less cited works. However, this is less true of the other fields, which show a much flatter distribution. This suggests that they are not being adopted in a focused way by design research – something that might be expected if specific or important works were having a significant impact. Third, only six sources from just three fields are represented in the top twenty-one most cited works. This both supports the previous point and highlights the extremely focused citation of the examined sample, with the top five sources accounting for over 14% of all citations.

These points allow for a tentative conclusion that despite some consideration there is little coherent uptake or impact of fields from outside the design domain within the corpus. In isolation it is difficult to identify the possible issues arising from this level of focus. However, based on the work of Winter (2008) and others (Reich, 1995, Blessing and Chakrabarti, 2009) it is likely that this disparity between within field citation and citation of other fields significantly impacts the scope of design research in terms of what research is considered acceptable to the community, the identification of new methods and the improvement of the field by comparison to our sometimes more advanced peers (highlighted by Winter (2008)).

5.2 Aspirations compared to reality

A key comparison in guiding this discussion is the distribution of citations in design research and the other fields. It would be expected that a field with a significant role/uptake in design research would show a similar distribution and magnitude of citations across sources as found within the design

research field itself, i.e. key sources are identified, cited, distributed, recited and become dominant with a tail-off in the citation of less significant works. Further, it should be expected that where fields are closely linked to specific topics and research aspirations they be proportionally represented in citations – forming the foundation for design specific work.

In this context the results from this study highlight a number of possible issues in the examined corpus. First, there is a mismatch between those fields associated with design research topics and their citation. For example, consider the key foundational role psychology literature and methods play in the investigation of design thinking or human behaviour in design (Table 2). However, despite this, psychology related citations only account for 4.9% of the overall distribution. Alone, this could be dismissed by claiming that design thinking and human behaviour in design only account for a small part of the community and, as such, this proportion of the total citations is appropriate. However, a second point highlights this issue from a different perspective: the distribution of citations to psychology is significantly different to the distribution of design related citations. In this case the psychology citations are distributed more evenly with a maximum of 8 citations to a single journal. This indicates that there are no clearly established key sources that form the foundation of work in design research. Combined, this overall low level of citation and the lack of cohesive citation of key sources suggest that work from this field has little penetration in design research despite its relevance to a wide range of design research topics.

This conclusion is supported by the same phenomena being true for all the identified fields other than management. In this case, management is the only other field that accounts for a significant portion of the citation distribution and also shows a distribution of citations similar to that observed in the design domain – suggesting that management literature is cited in a similar manner.

Based on this comparison of citation distribution and overall magnitude it is possible to conclude that design research does not effectively cite work in fields outside of management and that this seriously impacts uptake and adoption of key concepts. This is further supported by the work of Cash et al (2012) and others (Blessing and Chakrabarti, 2009, Ball and Ormerod, 2000, Reich, 1995) who highlight this phenomena as a key issue in design research.

5.3 Conference compared to journal

Finally, it is important to consider the generalisability of these findings – are they consistent with the journal based work of Chai and Xiao (2012) or do they highlight a more localized phenomena unique to a conference context. Here, Chai and Xiao highlight two extremely relevant points:

1. The significance of areas such as design cognition and protocol analysis as features of design research. This counters the possible argument that these areas are only marginal and thus should not expect to be represented in the citation distribution. As such, it is possible to conclude that the underrepresentation of these areas is a true finding indicative of the field rather than the limited scope of these specific areas.
2. Chai and Xiao (2012) find a very similar distribution of citations to that found in this study. This is further supported by the top twenty sources identified by Chai and Xiao, which are directly comparable to the results of this study in terms of distribution of fields and the relative citation count for primary sources in the other fields (Table 5 p.31 (Chai and Xiao, 2012)). Finally, they also highlight the sharp tail-off in citation to design sources compared to the flatter distribution of citation to other fields.

Based on these two points it can be concluded that despite the limited scope of the dataset considered for this study these findings are indicative of the overall field. This is particularly relevant as Design Studies and the DESIGN conference are highly rated in the field, suggesting that it is not a localized quality issue at the specific conference chosen for this study. Further, the fact that these findings are true for both a recent conference and historically in the journal corpus indicates that these are significant challenges facing the field as a whole.

5.4 Limitations

One important technical limitation was that although significant care was taken to correctly identify and categorize all citations there were a large number of errors, inconsistencies and incomplete citations in the papers, leading to a possible source of error. However, due to the extensive manual checking undertaken by the authors, possible errors from this source has been minimized. A second technical limitation is the use of only a single conference. However, as the aim of this study was to

characterize and compare the current state of the field it was considered an appropriate limitation of scope. In this regard the DESIGN 2012 conference was selected as the most current ‘snap-shot’ of the overall community, which was not limited to just one topic such as other events endorsed by Design Society.

In addition to the technical aspects, MacRoberts and MacRoberts (2007) and Smith (1981) highlight four further theoretical limitations of citation analysis.

First, from the analysis carried out in this paper it is difficult to identify the influence or impact of a specific manuscript or author. For example, some works might be frequently used as examples, whilst having a limited influence on an author. Although, this is a significant issue it is unlikely to affect the overall findings as these are focused on characterizing citations by field/source and, as such, do not rely on ascertaining the direct influence of individual works.

Second, possible bias can be introduced when authors do not cite the original work. For example, instead of citing the original source of a theory from psychology an author might simply refer to the most recent implementation of this theory in the design research domain. This has been addressed, in part, by the comparison of aspirations/topics and their likely associated fields (Table 2). This allows for an estimate to be made of the relative importance of each field and thus allow for a comparison between this estimate and the actual citation distribution. Through this comparison it is possible to establish in which areas this phenomena is most pronounced and thus allow for it to be addressed.

Third, the analysis does not differentiate between positive and negative citation. Although this is an issue when attempting to identify the impact of specific works it does not affect the findings of this study which are concerned with overall trends in citation distribution and are therefore relatively unaffected by the type of citation.

Fourth, similar to point three, self-citation cannot be differentiated from normal citation. Although this can cause bias it is unlikely that it is a significant factor as noted by Hyland (2003) who also highlights the important role self-citation plays in defining a field. Further, the type of analysis carried out in this paper is robust in this context – simply identifying such a citation as directed to a certain field and source rather than a specific author.

Ultimately, these limitations are the same as those experienced by Chai and Xaio (2012) and thus have little real effect on the comparative element of this paper. Further, as discussed in this section the field and source focused analysis is a robust approach, which is not substantially affected by the identified limitations.

6 CONCLUSIONS

This paper has presented a bibliometric analysis of the International Design Conference DESIGN 2012. Based on this analysis three major conclusions have been drawn.

First, the uptake and subsequent impact of research from domains outside of design is very limited. Further, it is likely that this limited uptake of work from relevant fields has a significant impact on methodological quality in design research. Second, where work from other domains is cited there is little focus, implying that there is limited scope for the identification of key works in fields other than management and that this seriously impacts uptake and adoption of important concepts and methods. Finally, by comparing this study to the work of Chai and Xaio (2012) it is possible to conclude that this is representative of the field as a whole and, significantly, supports and adds to Chai and Xaio’s examination of the journal *Design Studies*.

Based on these conclusions it is critical that a concerted effort is made by the community as well as individual authors to consider the wider scope of work from related fields, which have a direct and important impact on design research. This is particularly true of psychology and HCI. A more rigorous approach to considering such work will arguably lead to an improvement in overall research quality as well as directly impacting individual authors’ work. For example, consider the recent identification and application of psychological placebo control techniques in the design research domain by Cash et al. (2012).

Although the scope of this study has been intentionally limited there is significant opportunity for further exploration of the dataset using citation networks, an expansion of the study to other research fields (e.g. Freyne et al (2010)) in order to identify a baseline against which to compare design, or an expansion to other DESIGN conferences. Further, research is needed to examine the citation networks in more detail (e.g. are certain demographics or regions citing others preferentially) and how they change over time in order to most effectively target efforts at improvement and integration of research

outside of the design domain. Research of this type would also allow for an ongoing assessment to be made of uptake and research propagation over time in the design community – allowing community leaders such as the Design Society to target SIG's, keynote speakers and other tools for broadening research perspectives most effectively.

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