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A CO-AUTHORSHIP ANALYSIS OF PRODUCT AND INDUSTRIAL DESIGN EDUCATION LITERATURE, 2000-2015

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ABSTRACT
Today, collaboration is the norm rather than exception in scholarly publications. Through co-authorship scholars can increase the volume and quality of their scientific output. Utilising these networks, they establish knowledge communities, which shape how academic fields evolve. As such recognising the structure of these collaborations is important for understanding fields and their trajectories. This paper undertakes an exploratory quantitative analysis of co-authorship networks in industrial and product design literature extracted from Web of Science between 2000 and 2015. Results indicate that the number of co-authored papers is rising yet large research networks do not exist in this area.

Keywords: Co-authorship, social network analysis, bibliometrics, product design education, industrial design education

1 INTRODUCTION

Bibliometric analyses of the literature have become common place in many fields [1]–[9]. These analyses are invaluable as they help researchers identify evolution of ideas, emergence of trends and structure of collaboration networks in the extant literature. Typically, bibliometric studies come in four flavours: co-citation, bibliometric coupling, co-occurrence and co-authorship analyses.

Using a comprehensive sample extracted from Web of Science (WoS), this paper presents a preliminary co-authorship analysis of product and industrial design education literature between 2000 and 2015, as part of a larger study that quantitatively analyses the growth of design education [10] [11]. Bibliometric studies in design research are quite rare [12]–[16] and to my knowledge, there are none that deal with the topic of co-authorship.

Today, collaboration has become the norm across a vast majority of fields spanning from sciences to arts and humanities. Collaboration can happen in myriad ways, yet one of the most salient expressions of collaboration is co-authorship in scholarly publications. Through co-authorship researchers form communities and establish knowledge networks that contribute to the sustainable growth of academic disciplines [7]. Therefore, comprehending these relationships is salient in order to assess the development of a scholarly field.

In this paper, two different methods to investigate the phenomenon of co-authorship in product and industrial design education literature were used. First, social network analysis (SNA) is employed to better understand the structure of the collaboration network. Second, multivariate regression analyses are utilised to take a closer look at the determinants and impact of co-authorship. In the interest of space, these analyses are exploratory rather than explanatory.

2 DATA

Every bibliometric study starts with a boundary definition. This is typically achieved by selecting a set of journals or a set of keywords. This paper takes the second approach, as product & industrial design literature may appear across many different venues. To do so, the compound WoS Boolean operator TS= (educ* AND (“industrial design” OR “product design”)) is used and the search is limited to the sixteen years between 2000 and 2015. Basically, this operator extracted all items containing the exact phrase “industrial design” and any word starting with “educ” or the exact phrase “product design” and

any word starting with "educ" within their topic (including title, keywords and the abstract). This initial search yielded 673 articles. Then each abstract was separately read to further eliminate unrelated articles. Two more articles were dropped because of missing data issues. The final sample size is N=409 articles.
After the selection of the sample, the metadata is exported to three different software packages. VOSviewer is used for [10] for the visualisation of the co-authorship networks, R package igraph for obtaining network measures, and Stata for statistical analyses.

3 FINDINGS

3.1 General trends

Among 409 articles that were analysed, 297 of them are co-authored. Overall there are a total of 904 unique (some authors have more than one document) authors in the sample and the mean number of authors per article is 2.63 with a standard deviation of 1.55. The max number of authors for an article is 11(N=1). Figure 1 shows the co-authorship trends over the 16-year study period. Although there is a dip between 2011 and 2014, both the number of product/industrial design education related articles and the collaborations are increasing.

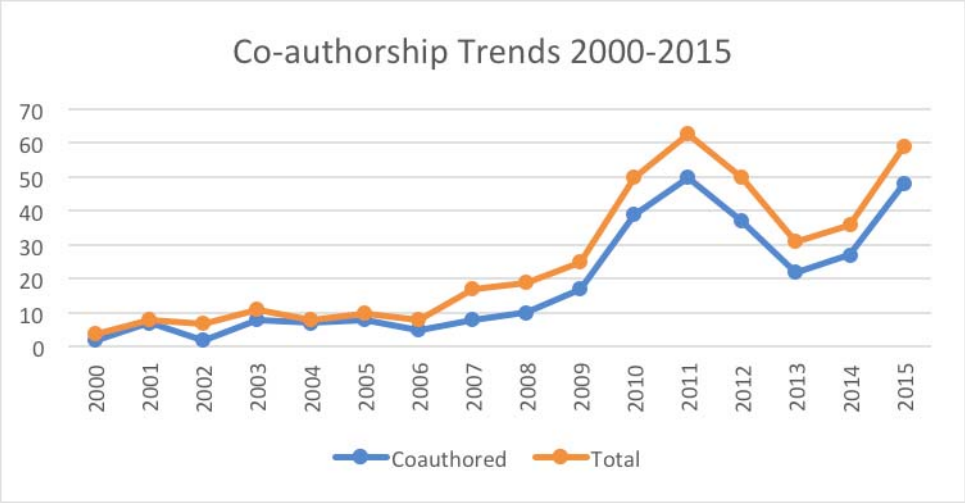

Figure 1. Co-authorship trends

3.2 Network measures

A social network is defined by nodes/vertices (in this case, authors) and edges/ties (in this case co-authorship relations) that link these nodes. A highly connected network with a large number of edges is dense. In network literature this is operationalise by "network density" which varies between zero and one [18]. If all the possible ties in a network are present this measure equals to one. For this network, overall network density is quite low (0.003). Although 73% of the articles are co-authored, these groups of co-authors are not well connected. This network's tendency toward small groups can also be analysed more formally through calculating the clustering coefficient [2]. Higher clustering coefficients mean more small groups. For this data clustering coefficient is 0.959 which is much higher relative to the other examples in the literature such as 0.681 for management [2] and 0.726 for physics [19].

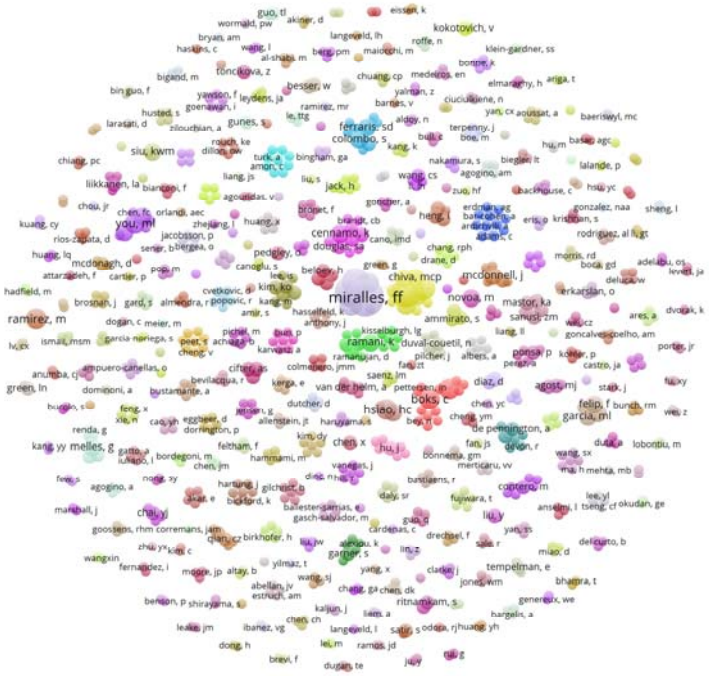

Figure 2. Co-authorship network, 2000-2015

There are a total of 229 distinct co-authorship groups (components in network language) in the sample. 80 of these groups are formed by two authors, 68 by three, 32 by four, 21 by five, 13 by six, six by seven, two by eight and two by nine. There is only one article for each of the 10,11,13,14 and 16 author groups. The largest component comprises only 1.8% of total authors.

Another important network feature is the relative importance of the nodes. Two important markers of the authors' prominence are degree centrality and betweenness centrality [18]. Degree centrality is the number of "all the direct links of an author (and could include several links to another researcher if they have worked together on a number of papers)" [2, p. 969]. Betweenness centrality on the other hand, indicates brokerage capacity of authors between different researchers. Actors that have high betweenness centrality scores, for example, are able to connect distinct groups, which are otherwise unconnected.

Table 1. Top 25 authors in terms of degree centrality and betweenness centrality

Author	**Degree Centrality**	**Author**	**Normalised betweenness**
miralles,ff	27	serrano,jg	.015
serrano,jg	25	escrig,ri	.013
martin,sm	21	ramani,k	.013
garcia-garcia,c	20	garcia-garcia,c	.009
martinez,mlg	19	douglas,sa	.007
escrig,ri	15	ferraris,sd	.003
ramani,k	15	gorno,r	.002
cennamo,k	13	mcgrath,m	.002
chiva,mcp	13	reimer,y	.002
lizandra,jln	13	vernon,m	.002
torre,am	13	bernstein,wz	.001
garcia,djd	12	cox,mf	.001
boks,c	11	garcia,djd	.001
mcgrath,m	11	zhao,f	.001
reimer,y	11	martin,sm	.001
vernon,m	11	martinez,mlg	.001
adams,c	10	chiva,mcp	.001
ardichvili,a	10	torre,am	.001
bar-cohen,a	10	miralles,ff	.001

beachy,r	10	boks,c	.001
cardozo,rn	10	diehl,jc	.001
durfee,wk	10	contero,m	.001
erdman,ag	10	hu,j	.001
hoey,m	10	you,ml	.001

Degree centrality and betweenness centrality measures for top 25 authors are shown in Table 1. The mean degree centrality of the whole network is 2.723 and mean betweenness centrality is practically 0. Top 25 authors have significantly higher scores than the mean values. These findings further underline the fact that the analysed co-authorship network consists of many small but unconnected groups. In other words, there is very little collaboration that last beyond a single paper. Furthermore, collaborations between authors that are in different institutions are rare. Indeed, when a collaboration network that takes institutions as the unit of analysis is created (not shown, available upon request), only 8 universities are connected through co-authorship relations.

3.3 Statistical analysis

This section complements the previous network analysis with two multivariate regression analyses predicting co-authorship and citation counts of the articles.

In line with the previous literature [2] the first analysis uses co-authorship (coded 1 when the article is co-authored, 0 otherwise) as a dependent variable. The independent variables are the page count of the article, whether the article was a journal article (coded 1 for journal articles, 0 for conference articles), growth trend and country dummy variables for Australia, China, Italy, Netherlands, Spain, Taiwan, Turkey, the UK and the US. These are countries with more than 10 articles in the database (Australia=27, China=60, Italy=18, Netherlands=24, Spain=44, Taiwan=21, Turkey=26, the UK=25 and the US=78). As the dependent variable is dichotomous, a logistic regression model was chosen. After the first data run, the dichotomous variable for Spain is dropped from the model as it perfectly predicts the outcome (in other words, all the papers from Spain are co-authored). The results of the model are presented in Table 2.

First and interestingly, time does not have a net effect on the co-authorship in this sample. Furthermore, and in contrast to previous studies [2], neither the length of the article nor its type (conference vs. journal) does not change the propensity of co-authorship.

Table 2. Logistic regression predicting co-authored articles, 2000-2015

Variable	Coefficient	Std. Error
Journal Article (Conference=0)	0.061	0.369
Page Count	-0.012	0.031
Time Trend	0.065	0.035
Australia	-0.630	0.452
China	-0.818*	0.361
Italy	0.935	0.793
Netherlands	0.558	0.574
Taiwan	0.354	0.570
Turkey	-0.916*	0.463
The UK	0.3148	0.529
The US	0.940*	0.410
Constant	0.249	0.468
N	365	
Pseudo R-Squared	0.07	

*p<0.05, two tailed tests

The only variables that have statistically significant effects on the dependent variable are three geographical origin variables. More specifically, papers from the US have a higher propensity of being co-authored while papers from China and Turkey have lower probabilities of being co-authored.
What about the effect of collaboration on the impact of an article? Impact of the articles is typically operationalised as the number of citations –although this measure is far from perfect—a specific article gets. The OLS regression in Table 3, which utilises the citation counts of articles as the dependent variable, answers this question. The independent variables are: a dichotomous variable operationalising if an article is co-authored (coded 1 for co-authored articles), whether the article was a journal article (coded 1 for journal articles, 0 for conference articles), growth trend (years) and geographic origin dummy variables.

Table 3. OLS regression predicting the impact an article, 2000-2015

Variable	Coefficient	Std. Error
Co-authored	0.402	0.439
Journal Article (Conference=0)	5.59***	0.461
Time Trend	-0.271***	0.054
Australia	1.937*	0.804
China	0.277	0.623
Italy	-0.224	0.999
Netherlands	-1.091	0.889
Spain	0.326	0.702
Taiwan	0.413	0.887
Turkey	0.275	0.833
The UK	-0.399	0.848
The US	0.612	0.574
Constant	2.939***	0.794
N	409	
R-Squared	0.35	

*p<0.05, ***p<0.001, two tailed tests

The results are again interesting and at odds with the previous literature that analyses other disciplines [2] [20]. Co-authorship has no statistically significant effect on the importance of an article measured by the total number of citations it receives. On the other hand, journal papers have a higher propensity of being cited compared to conference articles, controlling for all the other variables in the model. As expected, time has a negative impact on citation counts. From the geographical origin variables, only Australia is statistically significant. In this sample, papers originated in Australia are more likely to get more citations compared to the rest of the world.

4 DISCUSSION AND CONCLUSION

This article presented an exploratory quantitative analysis of co-authorship patterns in the product and industrial design education literature between 2000-2015 using SNA and statistical analyses. The results indicate that collaboration is increasing in this sample, following the general trend in many other fields. However, co-authorships are typically limited to single papers indicating a lack of long-term research programmes and productive research groups. Furthermore, the predictors that are utilised in two regression models behave differently than they did in previous research in other academic disciplines. Type and page count of the article are not statistically significant predictors of co-authorship. Similarly, article type and being co-authored does not affect the scholarly impact of an article measure by its citation count. Each scholarly area has its own dynamics and more research is needed to better understand reasons behind these findings.
The present research has a number of limitations. Since limited combinations of keyword strings in a limited time frame are used, some research regarding product and industrial design literature have been left out. Also, WoS is a quite selective database, and is not representative of the whole

scholarship done in this area. Interested researchers may use different key word combinations and databases (such as Scopus and Google Scholar) and different time frames to build on these findings. As this paper is exploratory, it opens up many fruitful avenues for future research.

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