A Timely Survey of Experimental Result Based Research in Computer Science

Pinaki Chakraborty, Anurag Dixit and P. C. Saxena

School of Computer and Systems Sciences, Jawaharlal Nehru University, New Delhi – 110067, India.
E-mail: pinaki_chakraborty_163@yahoo.com

Abstract

An empirical survey in 1995 found that the research literature of CS comprises of far less research papers with experimentally validated results in comparison to other sciences. This paper presents the findings of a survey of recent research literature in CS conducted using similar methodology. In this survey, 208 research papers from the journals and transactions published by ACM were examined. The papers were classified as formal theory based papers, experimental and empirical result based papers, hypothesis proposing and opinion papers, and survey and review papers. The thrust was on identifying the experimental result and empirical observations in these papers. It was observed that experimental and empirical result based papers consist more than 80% of the papers examined. This proves that the significance of experimentation in CS has increased considerably.

Keywords: *Computer science, experimentation, experimental result, empirical result, classification system*

1. Introduction

Computer scientists, alike their counterparts in other science disciplines, often propose new system designs, algorithms and models. The feasibility and utility of such concepts can be verified only by systematic experimentation. Now the question arises that whether the computer scientists bother to experimentally verify their theoretical claims? Tichy *et al*. [1] carried out an empirical survey of the then recent refereed research literature in Computer Science (CS) to answer this question and the observations were alarming. They found that there was a disproportionately high percentage of design and modeling work without any experimental evaluation. The observations suggested that large parts of research in CS might not meet the standards long established in natural and engineering sciences. After a comprehensive analysis of the observations, Tichy *et al*. [1] remarked that the situation cannot be expected to change overnight. More than a decade has passed since then and CS, as a discipline, has changed a lot. But has CS matured too? A timely survey of the refereed research literature in CS was carried out in similar lines of Tichy *et al*. [1] and the observations have been reported in the current paper. These observations will interest CS researchers as well as educators.

2. Related Work

In the context of the current paper, two types of research warrant mentioning. First, some earlier quantitative evaluations of experimental and empirical results in CS need to be mentioned. Second, some motivating works bespeaking experimentation in CS should be cited.

The first attempt to methodically assess the quantity of experimental work in CS was done by Tichy *et al*. [1]. The findings were encouraging neither for CS nor for the computer scientists. Around the same time, Mudge [2] also found the research literature of CS reporting unstructured inferences more often than developing rational models and hypotheses, and testing their validity. However, the reflections of Tichy *et al*. [1] were able enough to establish a school of literature analysis based research to evaluate the quality and quantity of experimental and empirical work in CS. Over the years, systematic literature review has evolved as a methodology for proficient analysis of research results [3].

Subsequently, multidimensional approaches to evaluate the research literature in CS have been developed. Glass *et al*. [4] divided the broad computing field into three subdivisions, viz., CS, software engineering (SE) and information systems (IS). Glass *et al*. [4] also presented a comparative study between the papers of these three subdivisions based on a comprehensive analysis of 1485 papers. In this study, a multidimensional classification scheme was used [5]. The empirical data for the CS, SE and IS subdivisions were reported by Ramesh *et al*. [6], Glass *et al*. [7] and Vessey *et al*. [8], respectively.

Tichy *et al*. [1] observed that the status of experimentation is worse in SE in comparison to CS as a whole. This led to the concentration of more efforts on experimentation in SE than perhaps any other discipline on CS. Zelkowitz and Wallace [9] carried on an early empirical study where they examined 612 papers on SE published in 1985, 1990 and 1995. They tried to determine the extent to which the papers validate the claims made in them. They observed that a large number of papers are not based on well planned experimentation. In a recent survey, 361 additional papers on SE published in 2000 and 2005 were examined using the same fundamental methodology [10]. It was observed that the situation is gradually improving and the much required culture of empirical research is crystallizing in CS. In another recent survey, a detailed examination and classification of 119 papers on SE was carried out and substantial number of papers reporting experimental results and empirical observations were identified [11]. Over the years, guidelines for empirical research in SE [12] and classification schemes for papers on SE [13] have been standardized.

Denning [14] defined CS as the science of information processes and their interactions with the real world. And, like other sciences, CS also needs to focus on experimentation. In fact, the importance of experimental and empirical results in CS has been recognized long ago [15]. Tichy [16] was early to logically explain why computer scientists must experiment and why experimentation cannot be avoided in CS. Similar remarks have been also made by several other reputed computer scientists since then. Feitelson [17] observed that only experimentation can confirm or controvert the relevance of established theories and practices. Basili and Zelkowitz [18] called for apposite interaction between theorists and experimentalists in CS. Important empirical concepts and skills have been also suggested to enhance experimentation in CS [19]. Lately, Freeman [20] found the recent emergence of sincere experimentation in CS to be phenomenal.

3. Materials and Methods

The current study has been carried out in similar lines of Tichy *et al*. [1]. However, little liberties have been taken to modify the process of selection of papers and their subsequent classification. Two basic conventions have been followed in this study. First, care was taken to examine a wide range of titles rather than a large number of papers on a few topics. Second, the data generated from the study have been processed and presented in multiple ways. It is expected that presenting the data in several simple ways will facilitate comparative studies in future. In fact, the conception of the current paper has been inspired by the simple yet potent thoughts of Tichy *et al*. [1].

3.1. Selection of the Papers

A wide set of peer reviewed research papers were sampled. The papers were selected from the journals and transactions published by the Association for Computing Machinery (ACM). ACM published 7 journals and 27 transactions in 2008 (Table 1). The journals and transactions have been generically referred as publications hereupon in this paper. All papers from the first issue of the volume of 2008 of each of these 34 publications were collected. For the publications whose last issue of the volume of 2007 was actually published in 2008, the first issue of the volume of 2008 has been considered. On the other hand, for the publications whose first issue of the volume of 2008 was actually published in 2007, the second issue of the volume of 2008 has been considered. All these publications use the ACM Computing Classification System [21] to categorize the papers. These ACM Computing Classification System categories of the papers have been used to interpret the observations in the current study. The ACM magazines, the two IEEE/ACM transactions and

the newsletters of the ACM Special Interest Groups (SIGs) were not considered in this study primarily because they do not use the ACM Computing Classification System. The conference papers were not considered in this study as they are often abridged reports of research and their enlarged editions are later republished in journals after a thorough review process [22]. In this way, 224 articles were collected. Later, it was found that 16 of them are editorials or similar articles. The rest 208 papers, which represent a fair cross section of peer reviewed literature in CS, were actually used in this study.

Table 1. List of publications examined

Source	Acronym
Journals	
ACM Computing Surveys	CSUR
Journal of the ACM	JACM
ACM Journal of Computer Documentation	JCD
Journal of Experimental Algorithmics	JEA
Journal on Educational Resources in Computing	JERIC
ACM Journal on Emerging Technologies in Computing Systems	JETC*
Journal on Computing and Cultural Heritage	JOCCH
Transactions	
ACM Transactions on Autonomous and Adaptive Systems	TAAS
ACM Transactions on Accessible Computing	TACCESS
ACM Transactions on Architecture and Code Optimization	TACO*
ACM Transactions on Algorithms	TALG
ACM Transactions on Asian Language Information Processing	TALIP
ACM Transactions on Applied Perception	TAP*
ACM Transactions on Embedded Computing Systems	TECS**
ACM Transactions on Information and System Security	TISSEC*
ACM Transactions on Knowledge Discovery from Data	TKDD*
ACM Transactions on Computer-Human Interaction	TOCHI*
ACM Transactions on Computational Logic	TOCL**
ACM Transactions on Computer Systems	TOCS
ACM Transactions on Design Automation of Electronic Systems	TODAES
ACM Transactions on Database Systems	TODS
ACM Transactions on Graphics	TOG
ACM Transactions on Information Systems	TOIS**
ACM Transactions on Internet Technology	TOIT**
ACM Transactions on Modeling and Computer Simulation	TOMACS**
ACM Transactions on Multimedia Computing, Communications, and Applications	TOMCCAP
ACM Transactions on Mathematical Software	TOMS
ACM Transactions on Programming Languages and Systems	TOPLAS**
ACM Transactions on Storage	TOS*
ACM Transactions on Software Engineering and Methodology	TOSEM**
ACM Transactions on Sensor Networks	TOSN
ACM Transactions on Reconfigurable Technology and Systems	TRETS
ACM Transactions on Speech and Language Processing	TSLP
ACM Transactions on the Web	TWEB

* The last issue of the volume of 2007 was actually published in 2008. Here, the first issue of the volume of 2008 is being considered.

** The first issue of the volume of 2008 was actually published in 2007. Here, the second issue of the volume of 2008 is being considered.

In the original study, two non-CS journals were also examined [1]. However, no such journal has been examined in the current study. The focus of the current study is to compare the state of CS research literature then and now, and not with that of other disciplines.

3.2. The Classification Scheme

The classification scheme used here is a modified version of the one originally used by Tichy *et al*. [1]. Here the research papers have been classified into four broad categories, viz.,

formal theory based papers, experimental and empirical result based papers, hypothesis proposing and opinion papers, and survey and review papers as defined below.

1. *Formal theory based papers*. This category consists of papers that present and/or prove theorems, lemmas and other such formal propositions.
2. *Experimental and empirical result based papers*. This category consists of papers that present data centric results. These are those results which cannot be obtained theoretically and are generated by experimentation and/or empirical research.
3. *Hypothesis proposing and opinion papers*. This category consists of papers that propose hypotheses or present some scientific opinion.
4. *Survey and review papers*. This category consists of papers that survey or systematically review a topic.

It should be noted that the classes of modeling and empirical papers of the original classification scheme have been merged into a single class in this scheme. The reason behind this is that the role of data centric results in CS is being investigated in this paper and both these two types of papers produce data centric results. The four categories described above cover almost all types of research papers and sufficiently satisfy the purpose of this study.

It is quite clear that the category of experimental and empirical result based papers is at the focus of the current study. So, these papers have been further classified on the basis of the amount of data centric results presented in them. The physical space devoted for presenting and interpreting observations and results has been used as the criterion of the further classification. Thus, the papers have been classified into ten subcategories of (a) 0%, (b) 0-10%, (c) 10-20%, (d) 20-30%, (e) 30-40%, (f) 40-50%, (g) 50-60%, (h) 60-70%, (i) 70-80%, (j) 80-90% of space per paper devoted to such materials. The trivial subcategory 2a represents papers that develop designs and models but do not validate them experimentally. Although space is a purely quantitative measurement, as in the original classification scheme, here also it is being believed to be indicative of the nature of the paper.

The current study, like the original one, does not attempt to assess quality of experimental work but it tries to identify what appears to be true experimental work. Now, the notion of true experimental work is largely subjective. Again, following the original study, experimentation characterized by testing claims in an objective and repeatable manner are being considered as true experimental work. Alternatively, demonstrations are being excluded from true experimental work. Simulations are being considered as true experimental work either if they are used to generate input data for some true experiments or if they use data from the real world and are conducted in realistic setups. In the current study, only the space used to present and interpret data centric observations and results is being measured. The space used to present the exact experimental setups and the conditions when the observations were made are also being considered in this measurement. However, generic discussions on the methodology, theoretical prediction of the outcome of the experiments, description of the system and algorithms are not being considered in this measurement.

Tichy *et al*. [1] have also analyzed the accuracy of their work. However, such an analysis has not been performed in the current study as the methodology used in the original study has been considered to be standard.

4. Observations

Tichy *et al*. [1] interpreted their observations primarily according to the publications examined. In the current study, the observations have been additionally interpreted according to major disciplines of CS.

4.1. Results Interpreted According to the Publications

Table 2 presents class sizes for the categories as defined in Subsection 3.2 whereas the complete classification data is given in the Appendix A. Figure 1 depicts the classes as percentages of the total number of papers in each sample and can be used to compare the results with those of

the original study. Three publications, viz., JACM, TALG and TOCL, published mostly formal theory based papers. Two publications, viz., CSUR and JOCCH published mostly survey and review papers. JETC and TOIT published a survey and review paper each. JERIC published the lone hypothesis proposing and opinion paper in the sampled set. All other papers were found to be experimental and empirical result based papers.

Table 2. Cardinalities of the papers presented according to publications

Publication	1	2										3	4	Total
		a	b	c	d	e	f	g	h	i	j			
CSUR	-	-	-	-	1	-	-	-	-	-	-	-	2	**3**
JACM	5	-	-	-	-	-	-	-	-	-	-	-	-	**5**
JEA	-	-	-	-	7	3	2	4	2	-	1	-	-	**19**
JERIC	-	1	-	1	-	-	-	-	-	-	-	1	-	**3**
JETC	-	1	-	-	-	1	-	-	-	-	-	-	1	**3**
JOCCH	-	-	-	-	-	-	-	-	-	-	-	-	6	**6**
TAAS	-	-	-	1	1	1	1	-	-	-	-	-	-	**4**
TACCESS	-	-	-	2	-	1	-	-	1	-	-	-	-	**4**
TACO	-	-	-	1	3	-	2	-	-	-	-	-	-	**6**
TALG	13	-	-	-	-	2	-	-	-	-	-	-	-	**15**
TALIP	-	-	-	1	2	-	-	-	-	-	-	-	-	**3**
TAP	-	-	-	-	1	2	2	-	-	-	-	-	-	**5**
TECS	-	1	-	4	6	2	1	-	-	-	-	-	-	**14**
TISSEC	-	-	2	-	1	-	-	-	-	-	-	-	-	**3**
TKDD	-	-	1	-	-	3	-	1	-	-	-	-	-	**5**
TOCHI	-	-	-	2	2	1	1	-	-	-	-	-	-	**6**
TOCL	7	-	-	-	-	-	-	-	-	-	-	-	-	**7**
TOCS	-	-	1	-	-	1	-	-	-	1	-	-	-	**3**
TODAES	-	-	2	5	7	1	1	3	-	1	-	-	-	**20**
TODS	-	1	-	-	1	2	1	-	-	-	-	-	-	**5**
TOG	-	-	1	1	1	6	-	-	-	-	-	-	-	**9**
TOIS	-	-	-	-	1	3	2	-	-	-	-	-	-	**6**
TOIT	-	-	-	2	-	-	1	-	-	-	-	-	1	**4**
TOMACS	-	-	-	2	1	-	1	-	-	-	-	-	-	**4**
TOMCCAP	-	-	-	1	4	-	1	1	1	-	-	-	-	**8**
TOMS	-	1	1	1	2	1	-	-	-	-	-	-	-	**6**
TOPLAS	-	3	1	1	-	-	-	-	-	-	-	-	-	**5**
TOS	-	-	-	-	2	1	-	-	-	-	-	-	-	**3**
TOSEM	-	-	-	1	2	1	-	1	-	-	-	-	-	**5**
TOSN	-	-	-	1	-	2	1	1	-	-	-	-	-	**5**
TRETS	-	-	-	-	1	2	1	1	-	-	-	-	-	**5**
TSLP	-	-	-	-	-	-	-	1	-	-	-	-	-	**1**
TWEB	-	-	-	2	1	4	-	-	1	-	-	-	-	**8**
Total	**25**	**8**	**9**	**29**	**47**	**40**	**18**	**13**	**5**	**2**	**1**	**1**	**10**	**208**

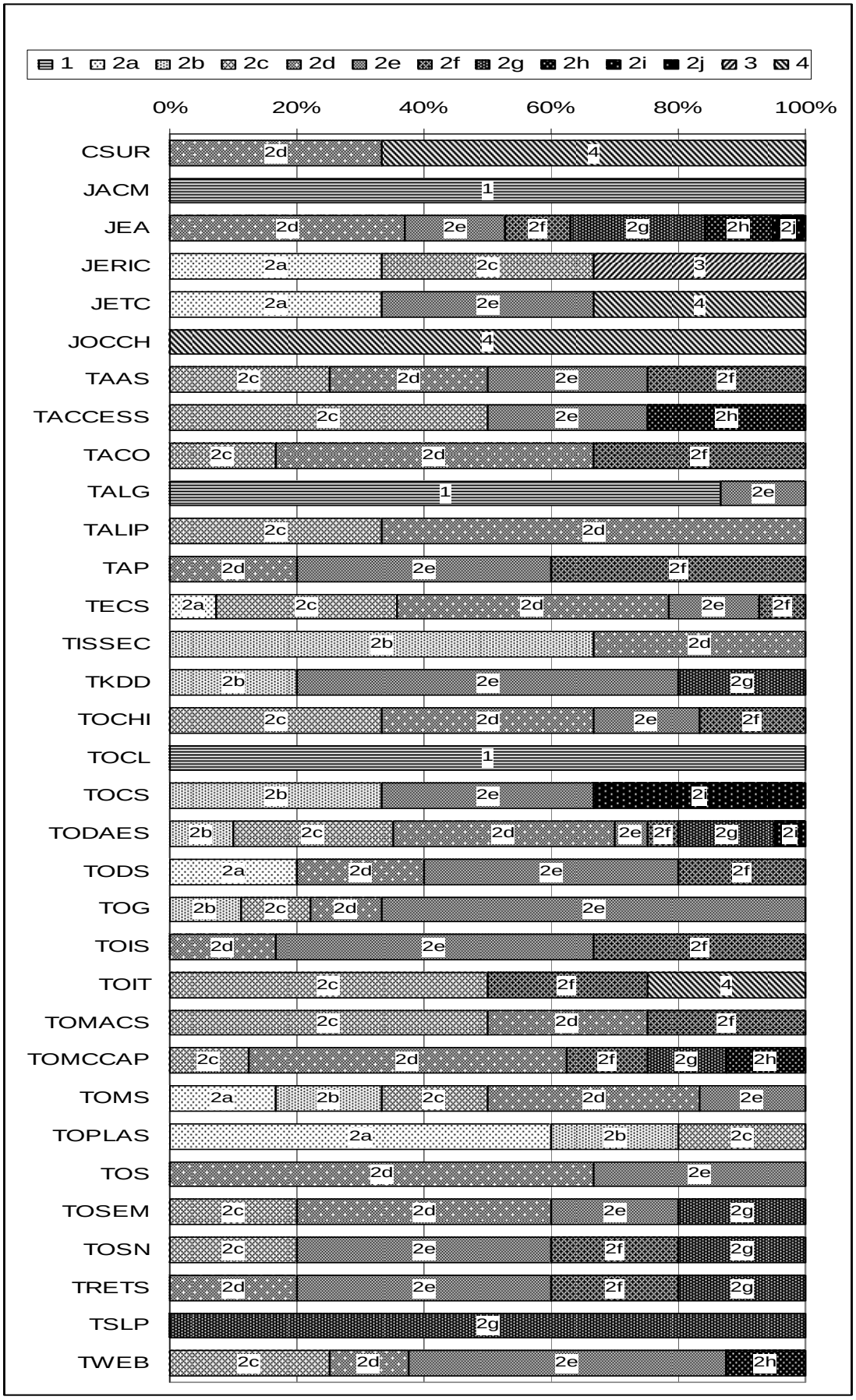

Figure 1: Relative cardinalities of the papers expressed according to publications

The overall distribution of the papers has been presented in Figure 2. From all these data, the following remarks can be made about the papers.

1. Formal theory based papers consist 12% of the papers examined and they are from three publications only. This indicates that theoretical works without experimental evaluation are no more entertained by most journals.
2. Experimental and empirical result based papers consist 83% of the papers examined and they constitute the majority in most publications. The original study [1] reported 18% and 7% of the total papers examined to contain design and modeling works with 0% and 0-10% physical space to describe experimental results, respectively. In the current study, both these figures were found to decrease to 4%. Alternatively, the original study reported that only 5%, 9% and 1% of the total papers examined devote 10-20%, 20-50% and more than 50% physical space to present and interpret experimental results. The current study found that these figures have risen to 14%, 50% and 10%, respectively. However, it should be noted that the figures of the original study content only experimental results while those of the current study also include empirical results. Nonetheless, the significant increase in the number of papers that report experimental results has to be acknowledged.
3. There was only one paper among those examined which can be classified as a hypothesis proposing and opinion paper.
4. Survey and review papers constitute 5% of the papers examined.

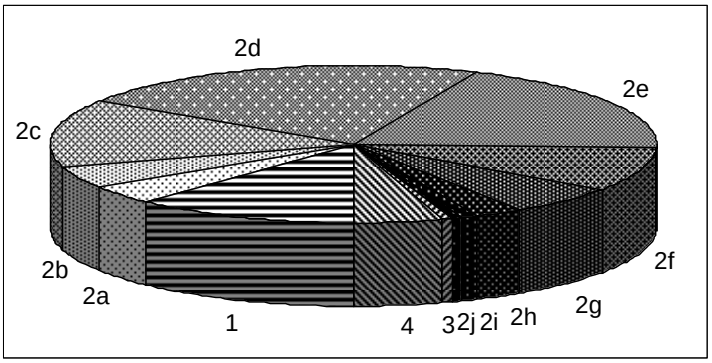

Figure 2: Overall distribution of the papers

4.2. Results Interpreted According to the Disciplines

The previous subsection presented the observations according to the publications. However, interpreting the observations according to the publications may not always reflect the condition of the experimental and empirical research in a discipline. Some publications are of general CS and many others are interdisciplinary. So, it is desirable to interpret the observations according to the disciplines. One of the most widely used logical classifications of disciplines in CS is the ACM Computing Classification System [21]. Table 3 presents the data according to the top two level of ACM Computing Classification System. Any class or subclass that does not have a paper has been excluded from the table and all consequent interpretations of the data. The relative cardinalities of the papers according to the disciplines have been illustrated in Figure 3 and summarized in Figure 4.

Table 3. Cardinalities of the papers presented according to disciplines

ACM CCS Category	1	2										3	4	Total
		a	b	c	d	e	f	g	h	i	j			
B	**-**	**-**	**1**	**8**	**9**	**4**	**3**	**1**	**2**	**-**	**-**	**-**	**-**	**28**
B.3	-	-	-	-	1	-	-	-	1	-	-	-	-	**2**
B.4	-	-	-	-	4	-	-	-	-	-	-	-	-	**4**
B.5	-	-	-	3	-	-	-	-	-	-	-	-	-	**3**
B.6	-	-	1	2	1	1	2	-	-	-	-	-	-	**7**
B.7	-	-	-	2	2	2	1	1	1	-	-	-	-	**9**
B.8	-	-	-	1	1	1	-	-	-	-	-	-	-	**3**
C	**4**	**2**	**4**	**11**	**18**	**4**	**11**	**3**	**1**	**1**	**1**	**-**	**-**	**60**
C.0	-	-	-	1	-	-	-	-	-	-	-	-	-	**1**
C.1	-	1	1	-	5	-	5	-	-	-	1	-	-	**13**
C.2	4	-	1	6	5	2	6	3	1	1	-	-	-	**29**
C.3	-	-	1	3	5	-	-	-	-	-	-	-	-	**9**
C.4	-	1	1	1	3	2	-	-	-	-	-	-	-	**8**
D	**2**	**13**	**15**	**9**	**20**	**6**	**6**	**1**	**-**	**-**	**-**	**-**	**5**	**77**
D.1	-	3	2	1	1	1	-	-	-	-	-	-	-	**8**
D.2	1	3	7	4	7	1	2	1	-	-	-	-	5	**31**
D.3	-	7	2	1	3	1	3	-	-	-	-	-	-	**17**
D.4	1	-	4	3	9	3	1	-	-	-	-	-	-	**21**
E	**4**	**-**	**-**	**-**	**4**	**2**	**1**	**1**	**1**	**-**	**1**	**-**	**-**	**14**
E.1	1	-	-	-	4	2	1	-	-	-	-	-	-	**8**
E.2	2	-	-	-	-	-	-	1	-	-	-	-	-	**3**
E.4	1	-	-	-	-	-	-	-	-	-	-	-	-	**1**
E.5	-	-	-	-	-	-	-	-	1	-	1	-	-	**2**
F	**27**	**1**	**-**	**2**	**7**	**4**	**-**	**2**	**2**	**-**	**-**	**-**	**-**	**45**
F.1	4	-	-	-	1	-	-	-	-	-	-	-	-	**5**
F.2	14	-	-	1	5	4	-	2	2	-	-	-	-	**28**
F.3	2	1	-	-	-	-	-	-	-	-	-	-	-	**3**
F.4	7	-	-	1	1	-	-	-	-	-	-	-	-	**9**
G	**4**	**1**	**1**	**2**	**8**	**10**	**3**	**2**	**-**	**-**	**-**	**-**	**1**	**32**
G.1	-	1	1	-	-	6	-	-	-	-	-	-	-	**8**
G.2	3	-	-	-	5	1	2	2	-	-	-	-	1	**14**
G.3	1	-	-	1	2	-	-	-	-	-	-	-	-	**4**
G.4	-	-	-	1	1	3	1	-	-	-	-	-	-	**6**
H	**6**	**1**	**1**	**13**	**17**	**32**	**8**	**4**	**6**	**1**	**-**	**-**	**20**	**109**
H.1	-	-	-	1	4	2	-	-	-	-	-	-	4	**11**
H.2	4	1	1	-	4	5	1	1	-	-	-	-	7	**24**
H.3	2	-	-	6	5	19	3	2	3	-	-	-	7	**47**
H.4	-	-	-	3	-	2	-	1	-	1	-	-	1	**8**
H.5	-	-	-	3	4	4	4	-	3	-	-	-	1	**19**
I	**6**	**-**	**1**	**9**	**14**	**16**	**2**	**2**	**-**	**-**	**-**	**-**	**4**	**54**
I.1	-	-	-	-	-	1	-	-	-	-	-	-	-	**1**
I.2	5	-	1	4	6	3	-	1	-	-	-	-	1	**21**
I.3	1	-	-	2	3	8	-	-	-	-	-	-	3	**17**
I.4	-	-	-	2	1	1	-	-	-	-	-	-	-	**4**
I.5	-	-	-	-	3	1	-	1	-	-	-	-	-	**5**
I.6	-	-	-	1	1	2	2	-	-	-	-	-	-	**6**
J	**-**	**-**	**1**	**1**	**6**	**5**	**4**	**-**	**-**	**-**	**-**	**-**	**5**	**22**
J.2	-	-	-	-	1	-	-	-	-	-	-	-	-	**1**
J.3	-	-	-	-	2	3	1	-	-	-	-	-	1	**7**
J.4	-	-	-	-	-	1	1	-	-	-	-	-	-	**2**
J.5	-	-	-	-	-	-	-	-	-	-	-	-	4	**4**
J.6	-	-	1	1	3	1	1	-	-	-	-	-	-	**7**
J.7	-	-	-	-	-	-	1	-	-	-	-	-	-	**1**
K	**1**	**2**	**2**	**7**	**2**	**-**	**1**	**-**	**1**	**-**	**-**	**1**	**4**	**21**
K.2	-	1	-	-	-	-	-	-	-	-	-	-	-	**1**
K.3	-	1	-	4	-	-	1	-	-	-	-	1	1	**8**
K.4	1	-	-	2	1	-	-	-	1	-	-	-	1	**6**
K.6	-	-	2	1	1	-	-	-	-	-	-	-	2	**6**

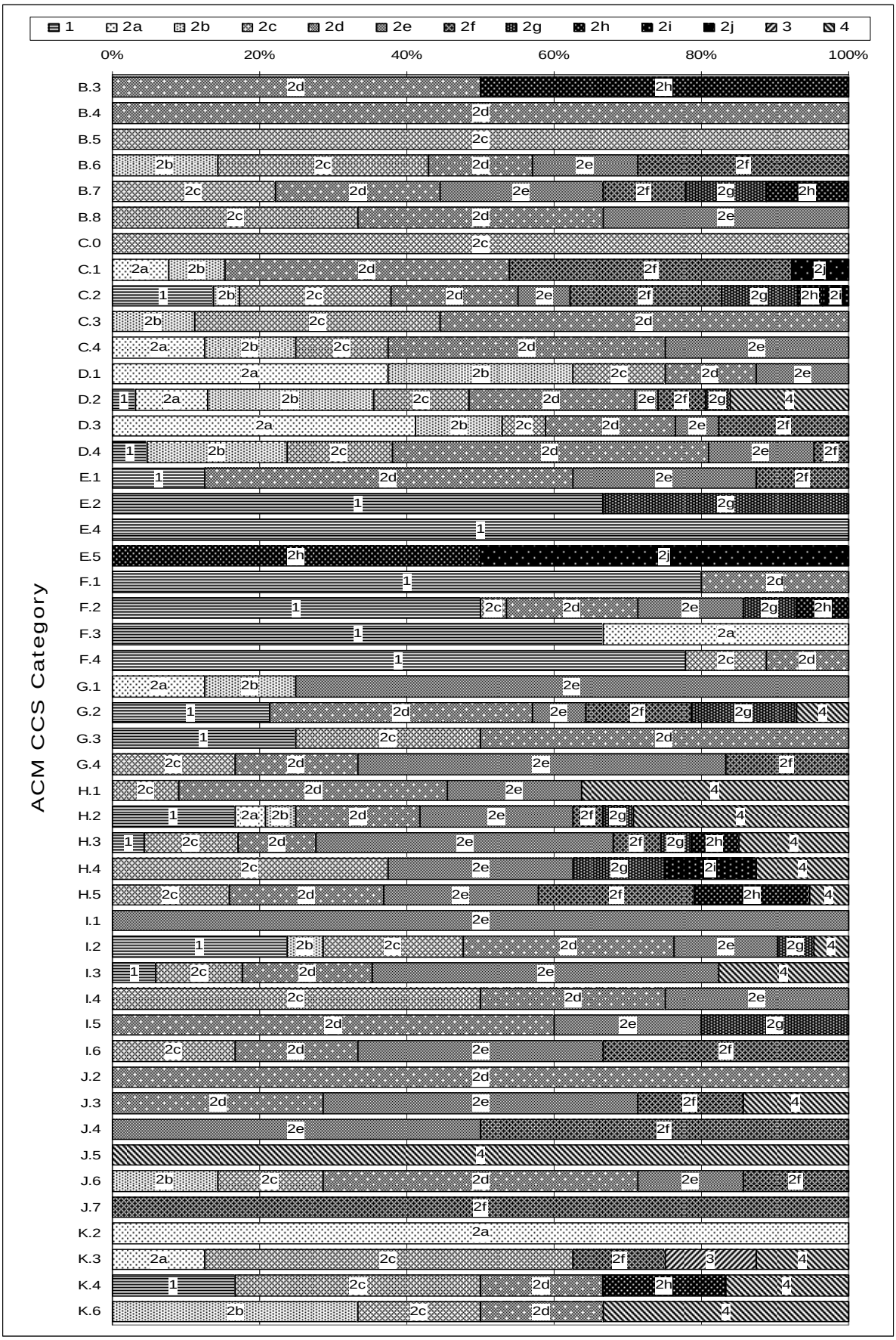

Figure 3: Relative cardinalities of the papers expressed according to disciplines

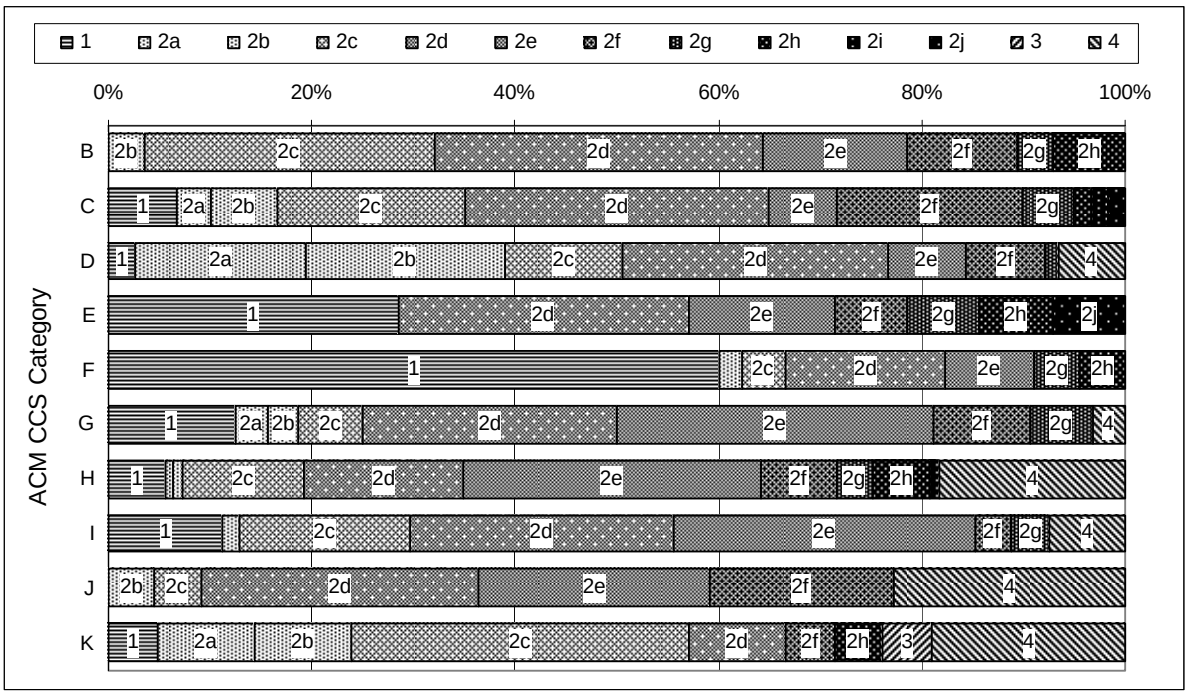

Figure 4: Summarized relative cardinalities of the papers expressed according to disciplines

Out of the papers examined, no paper on General Literature (ACM CCS Category - A) was found. The experimental and empirical result based papers constitute 40% to 100% of the papers belonging to all the other disciplines. In fact, they comprise all of the papers on Hardware (ACM CCS Category - B), 93% of the papers on Computer Systems Organization (ACM CCS Category - C), 91% of the papers on Software (ACM CCS Category - D), 71% of the papers on Data (ACM CCS Category - E), 40% of the papers on Theory of Computation (ACM CCS Category - F), 84% of the papers on Mathematics of Computing (ACM CCS Category - G), 76% of the papers on Information Systems (ACM CCS Category - H), 81% of the papers on Computing Methodologies (ACM CCS Category - I), 77% of the papers on Computer Applications (ACM CCS Category - J) and 71% of the papers on Computing Milieux (ACM CCS Category - K). The formal theory based papers are common in only two disciplines. They form 29% and 60% of the total papers on Data and Theory of Computation, respectively. The survey and review papers constitute 18%, 23% and 19% of the papers on Information Systems, Computer Applications and Computing Milieux, respectively. The lone hypothesis proposing and opinion paper is on Computing Milieux.

In this study, it was attempted to identify the areas that produce high proportions of experimental and empirical result based papers. Based on the observations, three such clusters were found (Figure 5). A large number of papers with 20-60% physical space devoted to experimental and empirical results are scattered among Hardware, Computer Systems Organization and Software disciplines. A moderate number of papers on Analysis of Algorithms and Problem Complexity (ACM CCS Category - F.2) have 20-60% of physical space devoted to experimental and empirical results. The third clusters of papers containing experimental and empirical results covering 20-60% of physical spaces are formed for papers on Mathematics of Computing, Information Systems and Computing Methodologies.

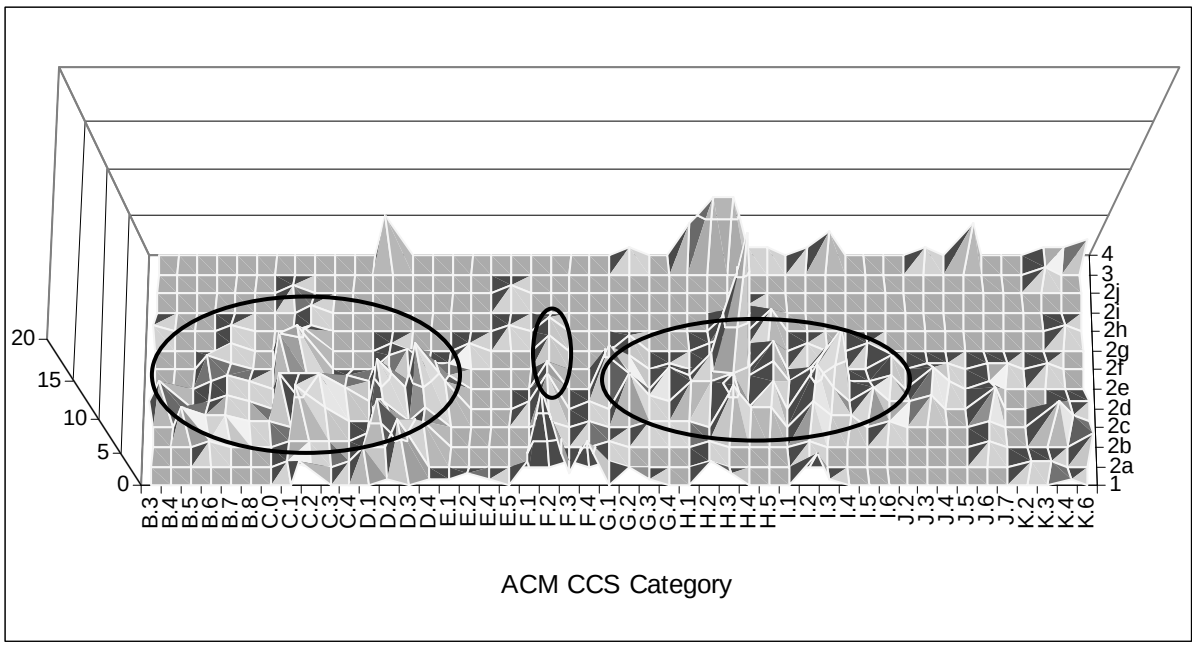

Figure 5: Identification of major areas of experimental research in CS

5. Discussion

The classification and the subsequent examination done in the current study, and all similar research, are ought to be subjective. It is understood that such a classification is open to debate and researchers are free to agree or disagree with it. Accordingly, the complete classification data of the current study has been presented in the Appendix A.

From this study, it can be resolved that experimentation has increased in CS over the years. There are quite a few factors that have led to this development. Firstly, several renowned computer scientists have campaigned energetically for providing more significance to experimental CS [9, 16-18, 20]. They made computer scientists understand why experimentation is necessary. Even more importantly, they discussed the demerits of research not verified by experimentation. Secondly, the journals have become more demanding over the years and now they do not encourage any theoretical research that is not verified by experimentation. Today, it is highly unlikely for a paper without experimental or empirical results to be published in a reputed journal unless the work is of extraordinary significance. Thirdly, the proliferation of information technology into almost every aspect of human life in the last decade has warranted trustworthy research in CS. This made the necessity of experimental and empirical research in CS felt. Lastly, the common computer scientists must be congratulated for their ongoing efforts to transform CS into a mature science.

6. Conclusions

It can be concluded that both the necessity and the significance of experimentation in CS has increased manifolds over the years. Now, experimental and empirical result based research papers form the core of the CS literature. This is substantiating the musings of Tichy [16], i.e., flourishing of the experimental branch of CS and ratification of CS as a fundamental science.

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Appendix A. Classification data

Publication	Article Number	Category	Publication	Article Number	Category	Publication	Article Number	Category	Publication	Article Number	Category
CSUR	1	4	TALG	1	1	TOCL	8	1	TOMACS	5	2c
	2	2d		2	1		9	1		6	2c
	3	4		3	1		10	1		7	2f
JACM	1	1		4	1		11	1		8	2d
	2	1		5	1		12	1	TOMCCAP	1	2d
	3	1		6	1		13	1		2	2d
	4	1		7	1		14	1		3	2g
	5	1		8	1	TOCS	1	2b		4	2d
JEA	1.1	2g		9	2e		2	2d		5	2d
	1.2	2e		10	1		3	2i		6	2c
	1.3	2e		11	1	TODAES	3	2c		7	2f
	1.4	2d		12	1		4	2c		8	2h
	1.5	2h		13	1		5	2h	TOMS	1	2e
	1.6	2f		14	2e		6	2d		2	2b
	1.7	2d		15	1		7	2b		3	2d
	1.8	2j	TALIP	1	2d		8	2f		4	2d
	1.9	2d		2	2d		9	2f		5	2a
	1.10	2d		3	2c		10	2b		6	2c
	1.11	2g	TAP	1	2f		11	2d	TOPLAS	7	2a
	2.2	2h		2	2d		12	2d		8	2b
	2.3	2g		3	2e		13	2e		9	2a
	2.4	2d		4	2e		14	2d		10	2c
	2.5	2d		5	2f		15	2c		11	2a
	3.2	2g	TECS	9	2d		16	2d	TOS	1	2d
	3.3	2e		10	2d		17	2d		2	2d
	3.4	2d		11	2d		18	2c		3	2e
	3.5	2f		12	2e		19	2c	TOSEM	7	2g
JERIC	1	3		13	2f		20	2d		8	2d
	2	2a		14	2d		21	2c		9	2d
	3	2c		15	2a		22	2f		10	2c
JETC	1	2a		16	2d	TODS	1	2d		11	2e
	2	2e		17	2c		2	2f	TOSN	1	2c
	3	4		18	2d		3	2e		2	2e
JOCCH	1	4		19	2c		4	2a		3	2f
	2	4		20	2c		5	2e		4	2e
	3	4		21	2c	TOG	1	2e		5	2g
	4	4		22	2e		2	2e	TRETS	3	2e
	5	4	TISSEC	2	2b		3	2e		4	2g
	6	4		3	2b		4	2e		5	2f
TAAS	1	2e		4	2d		5	2c		6	2d
	2	2c	TKDD	2	2b		6	1		7	2e
	3	2d		3	2e		7	2d	TSLP	4	2g

	4	2f		4	2e		8	2e		2	2e
TACCESS	3	2c		5	2g		9	2e		3	2e
	4	2h		6	2e	TOIS	6	2e		4	2e
	5	2c	TOCHI	1	2d		7	2d	TWEB	5	2h
	6	2e		2	2c		8	2e		6	2c
TACO	2	2d		3	2d		9	2e		7	2c
	3	2f		4	2f		10	2f		8	2d
	4	2f		5	2c		11	2f		9	2e
	5	2d		6	2e	TOIT	7	2f			
	6	2c					8	2c			
	7	2d					9	2c			
							10	4			

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