Keynote: Past, Present and Future of Engineering Education

P. Wankat[1]
Purdue University, USA
wankat@purdue.edu

B. Williams
Instituto Politécnico de Setúbal and CEG-IST/UTL, Portugal
Bill.Williams@estbarreiro.ips.pt

P. Neto
Instituto Politécnico de Setúbal, Portugal
Pedro.Neto@estbarreiro.ips.pt

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INTRODUCTION

Congratulations on the 40th anniversary of SEFI and the 38th anniversary of the *European Journal of Engineering Education* (*EJEE*). Anniversaries are a good time to reflect on past, present and future. We use bibliometric analysis, statistics, and historical and current literature to track the history of SEFI and *EJEE*, to determine where they are now, and hopefully to make an informed guess of their future. We analyzed the authors, citations and content of *EJEE* and *Journal of Engineering Education* (*JEE*) in the 1973, (1975 for *EJEE*), 1983, 1993, 2003, and available 2013 issues. Although bibliometric analysis and statistics provide hard data, the interpretation is filtered by the authors' personal knowledge. We start with a short narrative history of the journals that helps to explain some of the data and vice versa.

SHORT NARRATIVE HISTORY OF *JEE* AND *EJEE*

Some societal developments such as energy issues and sustainability impacted both journals while other developments such as the fall of the iron curtain had more impact on one journal (*EJEE* for this example). Both journals contained significant society news and other non-research material in the early years, and then slowly became more research oriented.

The history of *EJEE* is the history of a start up. In 1975 SEFI, which was officially created in January 19, 1973 at the University of Leuven in Belgium, had grown slowly from 75 to 122 to 150 members (Debruyn, 1975). *EJEE* was established in an attempt to remedy the unsatisfactory level of service provided to members. The

[1] Corresponding Author
P.C. Wankat
wankat@purdue.ed

journal would include the results of working groups. Debruyn, the president of SEFI, closed with a comment that starting a journal was a heavy financial load for SEFI.

The editorial board (Editorial Board *EJEE*, 1975) positioned the journal to include:

1. scholarly articles and documented analytical reports,
2. description of institutions of systems in member countries,
3. editorials and letters to the editor to engender discussion,
4. in-depth reviews of books, and
5. news and features on SEFI.

Thus, SEFI apparently did not originally intend for *EJEE* to become the major research journal it has matured into.

The first issue included a paper from the 1974 SEFI conference in Manchester. This started a tradition that continued for a number of years including the first 1983 issue which consisted of contributions from a seminar on continuing engineering education at the Polytechnic Central London, and the third issue in 1983 had working panel results. A major issue at this time in both *EJEE* and *JEE* was falling enrollment.

In 1989 the iron curtain fell, in 1990 Germany was reunited, and in 1991 the Soviet Union dissolved. Who believed in 1988 that such a sentence could be written? Europe, SEFI, and *EJEE* had an enormous amount of work to do. This work was still continuing in 1993 and *EJEE* published papers from 1990 and 1992 SEFI conferences plus a number of reports. The other major interests were continuing engineering education and quality management in engineering education.

By 2003 *EJEE* had changed and the journal has the look and feel of an international research journal. There were significantly fewer reports about engineering education at a specific institution or in a specific country, and papers that reported on conditions at a specific location were generally from outside of Europe. *EJEE* appears to have reached maturity as a research journal.

In the 1970s US engineering education was recovering from the anti-technology fallout of the Vietnam War and in 1973 the key topic in *Engineering Education,* the official journal of the American Society for Engineering Education (ASEE), was falling engineering enrollment. However, by 1983 enrollments had rebounded to new highs and the November 1983 issue of *Engineering Education* highlighted papers on “Managing Large Classes” and “Alternatives to Limiting Enrollments.”

In the late 1980s ASEE decided it was time for a face lift and makeover of *Engineering Education*. In August 1991 *Engineering Education* was retired after 81 years, and in September the first regular issue of ASEE *PRISM*, a news and general interest magazine, was published. The new quarterly *Journal of Engineering Education* was announced in 1991 to begin in 1992 but was delayed until January 1993. *JEE* was recast as a publication focusing on scholarly teaching responding to Boyer’s (1990) paradigm shifting *Scholarship Reconsidered.* In the first issue Felder et al (1993) quietly ushered in rigorous engineering education research supported by the US National Science Foundation (NSF). In 2003’s first issue 31% of the papers and in 2013 all of the papers with US authors acknowledge NSF support. US engineering education research is no longer a hobby but is now a profession.

In the late 1990s the Engineering Accreditation Commission (ECC) of ABET heeded the calls for reform with outcomes based accreditation – ECC2000. At the turn of the century many *JEE* papers were concerned with assessing student work to prepare for ABET. EC2000 has been credited with improving undergraduate education (Lattuca et al, 2006). Student learning of professional outcomes (teamwork, ethics, communication, understanding globalization, and lifelong learning) has improved.

Although the assumption may not be valid, current *JEE* papers often inherently assume that research will guide engineering education practice. For example, Diefes-Dux et al (2013, p.179) wrote, "This paper illustrates how interpretations of student teams' solution models…can be used to inform educational decisions."

AUTHOR AND CITATION DATA

Table 1 lists the raw data on the authors and papers in *EJEE* and *JEE*. All of the authors of the first issue of *EJEE* were from Europe, but that rapidly changed.

Table 1. Author Data for *EJEE* and *Engineering Education*/*JEE*
Note: The history of ASEE by Reynolds & Seely, *JEE,82* (3), 136-151 (1993) is not included in Tables 1 to 4 since the total number of citations (213) and the number of engineering education citations (208) are extreme outliers. The next largest number of total citations is 69 and of engineering education citations is 21.

YEAR	NUMBER PAPERS	NUMBER AUTHORS	AUTHORS PAPER	# SINGLE AUTHOR PAPERS (%)	NUMBER OF COUNTRIES	TOP 2 COUNTRIES FOR # OF AUTHORS (% AUTHORS)
EJEE						
2013 (ISSUES #1 - 3)	27	64	2.4	9 (33.3%)	19	US (28.1%), THE NETHERLANDS (9.4%)
2003	44	100	2.3	16 (36.4%)	22	US (15.7%), THE NETHERLANDS (13.9%)
1993	53	83	1.6	39 (73.6%)	24	UK (20.5%), GERMANY (12.0%)
1983	54	61	1.1	43 (79.6%)	15	UK (23.0%), FRANCE (14.8%)
1975	9	11	1.2	8 (88.9%)	6	UK (36.4%), DENMARK (27.3%)
TOTALS OR AVG	187	319	1.7	115 (61.5%)	44	UK (15.3%), US (12.9%)
ENGINEERING EDUCATION/JEE						
2013 (ISSUE #1)	7	24	3.4	1 (14.3%)	5	US (79%), DENMARK (8.3%)
2003	38	108	2.8	3 (7.9%)	5	US (91.7%), CANADA (3.7%)
1993 (JEE)	36	71	2.0	17 (45.9%)	2	US (98.6%), CANADA (1.4%)
1983 (ENGR ED)	59	85	1.4	38 (64.4%)	3	US (96.3%), CANADA (2.4%))
1973	113	160	1.4	79 (69.9%)	3	US (94.4%), CANADA (4.4%)
TOTALS OR AVG	253	446	1.8	138 (54.5%)	10	US (94.4%), CANADA (3.1%)

EJEE currently publishes authors from all over the world. *EJEE* authors have come from the following 44 countries: Algeria, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, Columbia, Cyprus, Czechoslovakia (before the split into the Czech Republic and Slovakia), Denmark, Finland, France, Germany, Ghana, Greece, Hong Kong, Hungary, India, Iraq, Ireland, Israel, Italy, Japan, Jordan, Kazakhstan, Korea, Lithuania, Malaysia, Malta, Norway, Poland, Portugal, Saudi Arabia, Slovenia, South Africa, Spain, Sweden, Switzerland, The Netherlands, Trinidad, United Kingdom, and United States.

The geographical spread of the authors of *JEE* is significantly less broad than that of *EJEE*. If the data is representative of all years, 97.5% of the authors are from the US and Canada and the remaining eight countries (Denmark, Greece, Hong Kong, India, Nigeria, Singapore, Thailand, and United Kingdom) share the remaining 2.5%.

The data in Table 1 show a marked reduction in the percentage of papers written by single authors and increased collaboration of authors in both *EJEE* and *JEE*. In both journals, although more pronounced in *JEE,* the number of authors per paper starts low and increases. There was also an increase in papers written by collaborators from different countries. *EJEE* had no multiple country collaborations in 1975 and 1993, 3 papers (5.6%) in 1983, 6 papers (13.6%) in 2003 and 5 papers (18.5%) in 2013. *JEE* had no multiple country collaborations in 1975, 1983 and 1993, 3 papers (7.9%) in 2003 and 3 papers (28.6%) in 2013. The authors of this paper can testify that the Internet makes collaboration across countries and across oceans possible.

Table 2 shows that both journals have rapidly increased the average number of citations per paper, although *JEE*, the older journal, started out higher and has remained higher. The numbers of citations in both journals has become large enough that levelling off or reduction of the number of citations would help readers. Citations to some extent illustrate an author's breath of scholarship. Self-citations have been separated out since they do not illustrate breath.

Table 2. Citation Data for *EJEE* and *Engineering Education*/*JEE*

YEAR	EJEE # CITS	EJEE #CITS PAPER	EJEE # SELF CITS	EJEE % SELF CITS		ENGR ED/JEE # CITS	JEE #CITS PAPER	JEE # SELF CITS	JEE % SELF CITS
2013	812	30.1	43	5.3%		368	52.6	60	16.3%
2003	634	14.4	54	8.5%		934	24.3	59	6.4%
1993	247	4.7	19	7.7%		444	12.3	55	12.4%
1983	52	1.0	5	9.6%		463	7.8	31	6.6%
1975 EJEE 1973 ENGR ED.	9	1.0	0	0		429	3.8	17	4.1%
TOTALS OR AVG	1754	9.4	121	6.9%		2638	10.8	223	8.1%

Tables 3 and 4 show what sources are cited. Table 3 is a relatively complete listing of journal sources, but does not include URL and government reports that are included in the total number of citations. The listings in Table 4 were truncated because many engineering textbooks, education journals and books were cited only once or twice.

Since *Engineering Education* was over sixty years old in 1973, its citation pattern was fully developed. The most cited source is the journal itself, which is the common pattern for engineering education journals (Wankat, 2011). 1993 was a watershed year because *JEE* had a different focus than *Engineering Education.* The increase in citations/paper in Table 2 and the difference in sources cited in Tables 3 and 4 from 2003 to 2013 compared to 1973 to 1993 reflects ***JEE's*** more scholarly and later rigorous research approach.

Since *EJEE* was new, there were few early *EJEE* papers to cite for several years. As a result *EJEE* did not become the most cited journal in *EJEE* until sometime between 1993 and 2003. During this period *EJEE* also served as the news magazine for SEFI and there are a significant number of citations of reports and meetings.

The data from 1975 to 1993 is shaded in Tables 3 and 4 to separate the start-up period of *EJEE* from its more mature phase in 2003 plus 2013. There are 72 citations

of engineering education sources from 1975 to 1993. If we assume the citation pattern is the same in 2003 plus 2013, we can find the expected value as follows:

Expected Value Engr Ed 2003 and 2013= (# Engr Ed 1975 to 1993) × [(# total 2003 and 2013)/(# total 1975 to 1993)] = (72) × [(1446)/(308)] = 388 citations,

which is significantly less than the 484 engineering education citations observed. From Table 4 the expected value of *EJEE* Engineering and Science citations in 2003 and 2013 = (52)(1446)/(308) =244 versus 177 observed. The expected value of *EJEE* Education citations in 2003 and 2013 is 314 versus 525 observed. We interpret these effects as due to the maturing of *EJEE* by substituting engineering education publications for engineering, math or science citations and substituting education and psychology publications for various reports.

Table 3. Engineering Education Sources in *EJEE* and *JEE.* * 8 cited in one paper.

	EJEE						*ENGR EDUC/JEE*				
YEAR	75	83	93	2003	13		73	83	93	03	13
TOTAL ENGINEERING EDUC CITS=	**1**	**23**	**48**	**222**	**262**		**141**	**160**	**184**	**365**	**106**
SELECTED ENGR EDUC SOURCES											
EJEE		3	1	28	46					6	5
SEFI MEETINGS		6	1	15	3					1	
SEFI LITERATURE		5	5	4	0						
IEEE TRANSACTIONS EDUCATION		1	1	1	6		6	3		9	
JEE (AKA *ENGR EDUCATION)*			3	24	35		32	64	59	99	41
INTL J ENGR ED (IJEE). ORIGINAL NAME *INT J APPLD ENGR ED*			1	25	11				6	2	14
PROC. ASEE/IEEE FRONTIERS EDUC. CONF (FIE)			1	1	8		5	7	5	42	4
PROC INTL SEMINAR IMPROVE GENDER BAL. ENG. EDUC USING ICT METHODS				14*							
J WOMEN & MINORITIES SCI & ENGR				2							
PROCEED. ASEE ANNUAL MEET				8	30		7	6	28	29	7
ABET				4	3			5	3		1
GLOBAL J. ENGINEERING ED.				7*						2	
ASEE PRISM				1					6	9	
ASEE REPORTS		1	1		1		1	2	8	2	
ASEE REGIONAL CONFERENCES					1			2	7	4	
ADVANCES ENGR EDUCATION					1						1
CHEMICAL ENGR EDUCATION					9*		2	1	1	4	1
COMPUTER APS ENGR EDUC					3					1	
J. PROF. ISSUES EDUC. & PRACTICE					15				4	1	1
ERM J (ED RSCH METHODS DIV ASEE)							7	1			
ASEE CASE STUDY FILES							3	10			
AUSTRLASIAN J ENGR ED.										1	

1993 was the first year for *JEE* after the transition from *Engineering Education*. Since the citations are closer to 1983 than to 2003, we have situated 1993 data with 1983 and 1973. Based on the total citations (Table 2) the expected value of engineering education citations is 473 versus 471 observed, of engineering and science citations 255 versus 137 observed, and of education citations is 379 versus 608 observed. Our interpretation is that for the more mature journal the pattern of engineering

education citations did not change, but *JEE's* positioning as accepting only rigorous EER papers encouraged the continued increase of psychology/education citations and decrease in engineering/science citations.

Table 4. Engineering & Science, Education and Other Sources in *EJEE* and *JEE.*

	EJEE						***ENGR EDUC/JEE***				
	1975	1983	1993	2003	2013		1973	83	93	03	13
ENGR & SCIENCE TOTAL CITS =	**0**	**3**	**49**	**100**	**77**		**96**	**88**	**78**	**88**	**49**
SELECTED ENGR & SCIENCE SOURCE											
IEEE SPECTRUM			2	2			2	7	1	3	
IEEE PROCEEDINGS							4	4		1	
MECHANICAL ENGINEERING				7			2	1	1		
SCIENCE				1			8	3	3	4	
NATURE							2			2	1
ISSUES SCIENCE & TECHNOLOGY									3	3	1
THE BRIDGE (NATL ACAD. ENGR.)				3				1	1	7	2
PSYCH/EDUCATION TOTAL CITS =	**6**	**16**	**45**	**193**	**332**		**141**	**152**	**96**	**421**	**187**
PSYCH/EDUC SELECTED SOURCES											
BRITISH J ED TECHNOLOGY	1				8					1	
CHRONICLE HIGHER EDUCATION							1	6	1	8	1
CHANGE								1	2	3	
EDUCATIONAL TECHNOLOGY R&D			2		1					4	
EDUC. PSYCH MEASUREMENT							4	2			
INTL. J SCIENCE EDUCATION				2							5
J HIGHER EDUCATION					5		1			2	
J ED PSYCH				1	10		1	3			
J LEARNING SCI.										1	10
REVIEW EDUC. RESEARCH					1		1	1	1	1	
REVIEW RESEARCH EDUC.					1				1	1	
COMPUTERS IN EDUCATION					5					5	1
BRANSFORD ET AL., *HOW PEOPLE LEARN*				2						6	2
BLOOM ET AL., *TAXONOMY*		1		2	1		1			2	
MISC. SOURCES											
HARVARD BUSINESS REVIEW			2	3	1				1		
IEEE TRANS. ENGR. MGMT.					5*		1				
IEEE TRANS. PROF. COMMUNIC							5			9	

REFERENCE DISCIPLINE ANALYSIS

Over the past two decades reference discipline data have been studied in emergent disciplinary fields such as Information Systems and Enterprise Engineering research (Grover et al 2006, Liles & Johnson 1996, Wade et al 2006) and EER (Williams et al. 2013). Reference discipline analysis studies the disciplines referenced and cited in research papers to track the developing maturity of a research field. It assumes that an emerging research area will depend largely on existing disciplines in the early stages; gradually generate more internal theoretical concepts, frameworks and models; and in a mature stage, serve as a reference discipline for other disciplines.

We selected original articles included in the first issues of each year, classified them as non-research or research and the research papers were analyzed as to the

reference disciplines used to support their research. As the number of papers in *EJEE* in the early issues was small, we combined those for 1974 and 1975 giving a total of 13 papers. In the case of 2013 only 18 *EJEE* and 7 *JEE* articles had been published at the time of writing.

Decisions as to which were research articles as distinct from essays, curriculum proposals or descriptive texts (all of which were frequent in the earlier days of both journals) were based on the guiding principles proposed by Shavelson and Towne (2002). We considered research articles to be those which fulfilled three or more of the following six principles:

- Pose significant questions that can be investigated empirically.
- Link research to relevant theory.
- Use methods that permit direct investigation of the question.
- Provide a coherent and explicit chain of reasoning.
- Replicate and generalize across studies.
- Disclose research to encourage professional scrutiny and critique

For the reference discipline analysis, our classification system required authors to specifically show that the discipline underpinned their research. Such references were normally cited in the background or methodology sections of papers and were frequently mentioned as keywords. Disciplines appearing only in the bibliographic references section were not considered reference disciplines. Each journal article was classified independently by two authors and the classifications later discussed until they were consensual. The results are shown in Figures 1 and 2 and in Table 5.

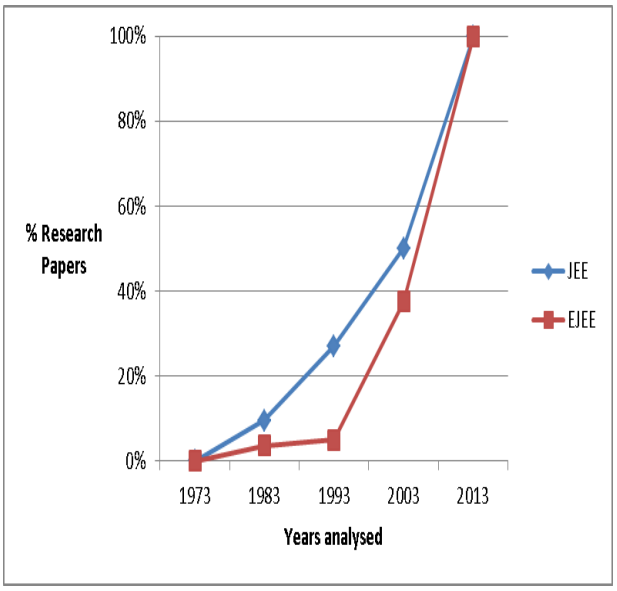

Fig. 1 Percentage Research Papers

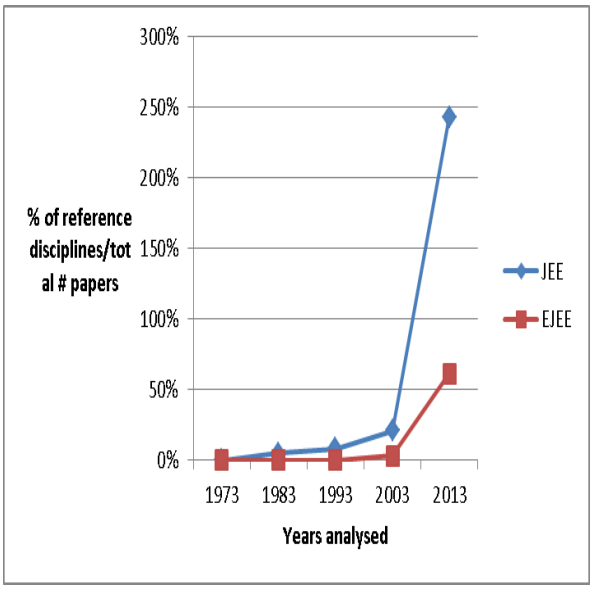

Fig. 2. Reference Disciplines

The trend in both *JEE* and *EJEE* papers is broadly similar although notably more accentuated in the former. Initially there were little or no research papers in the 70's and 80's and then there was gradually increasing research content with an occasional reference discipline (typically psychology). By 2013 there was a very significant number of reference disciplines drawn upon – 61% for *EJEE* and 243% for *JEE*. Given that the 2013 figures may be less reliable due to the smaller sample size, we have also compared them with an analysis of both journals with a larger sample size in 2011 and found a broadly similar pattern although in the case of *JEE* less pronounced – *EJEE* 48% and *JEE* 105% (Williams et al. 2013).

Table 5. Statistics for Reference Discipline Analysis

		EJEE						***JEE***				
Source/Year		75	83	93	03	13		73	83	93	03	13
# Papers Analyzed		13	28	20	32	18		24	21	37	24	7
Classified as Research Papers	#	0	1	1	12	18	#	0	2	10	12	7
	%	0	4	5	38	100	%	0	10	27	50	100
Classified as having Reference Discipline	#	0	0	0	1	11	#	0	1	3	5	17
	%	0	0	0	3	61	%	0	5	8	21	243

CONCLUSION

Both journals followed similar trends. They progressed from opinion essays, reports, and descriptive articles to research articles. There was a qualitative evolution in breath of scholarship with increasingly interdisciplinary research articles with more collaboration and more references. This is more accentuated in *JEE*. *JEE* and *EJEE* both became more frequently cited. The international character of both journals has also evolved over the 40 years – geographical spread is notably broader in *EJEE*.

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