A Bibliometrics Analysis of Australasian Computing Education Conference Proceedings

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ABSTRACT

The Australasian Computing Education (ACE) conference is one of the key attractions for the computer science education research community, particularly in the Asia-Pacific region. Throughout its twenty three sessions, different authors representing multiple affiliations have submitted their research papers to ACE. The aim of this study is to identify the main topics that have been of interest to the ACE community and analyse the trends in topics and their evolution throughout time. We use a Bibliometrics approach to explore the metadata of all research papers published in ACE and report on the results of our analysis.

CCS CONCEPTS

• **Social and professional topics** → **Computing education**.

KEYWORDS

Computing education, classifying publications, bibliometrics

1 INTRODUCTION

The Australasian Computing Education Conference (ACE) is a high-quality international conference, providing a forum for educators and researchers to share innovations and insights in computing education. The conference was initiated in 1996 with a goal of presenting research papers focused on the use of technology in computing education, course content, curriculum structure, methods of assessment, pedagogy and learning theories, online learning, and evaluations of alternative approaches. A number of papers published in ACE have attempted to examine the conference proceedings as well as their metadata to explore different dimensions such as the context, scope, nature, and theme of the papers submitted to ACE throughout time. The first paper in this series is the *Ten years of the Australasian Computing Education Conference* [26] published by Simon in 2009. In that study, the author used Simon's system [6, 25] for classifying computing education papers to examine ten years of proceedings from the conference and also provided an analysis of the authors who target ACE. In a similar vein, Lister and Box [16] performed a citation analysis of the 43 papers published in the first three years of International Computing Education Research (ICER) conference. In that study, authors provided a map of ICER papers referencing ACE publications. Ten years later, Simon [27] explored 22 ACE conference proceedings' metadata to examine the same four dimensions analysed 10 years prior. In that study, he also examined the metadata of the authors to provide insights around the contribution, persistence, sociability as well as authorship patterns of authors publishing in ACE. In the same spirit, this study presents a Bibliometrics analysis [19] of all papers published in the proceedings of ACE conference. The contributions of this paper include analysis of the themes, authors, contributing countries, citation analysis, papers, intellectual structure as well as social structure of the papers and their authors. In particular, we are interested in characterising the themes that the ACE community has focused on and how those themes have changed over time. To that end, this paper attempts to answer the following research questions:

- What are the main themes explored in ACE papers?
- What are the changes in the themes explored by ACE authors?

We also address the questions:

- To what extent do ACE authors cross-collaborate?
- To what extent do ACE authors continue to contribute to the ACE community?

2 METHODS

To prepare the dataset used in this study, we collected the original BibTex files of the all research papers published in the proceedings of ACE (available at https://doi.org/10.5281/zenodo.5709243) from the Association of Computing Machinery's digital library (N = 545). These BibTex files provided us with the titles, publication year, list of authors, and digital object identifier of all the research papers published in ACE. Upon manual examination of these papers, it was noticed that for a large number of BibTex records, some information required for Bibliometrics analysis are not present. Examples of such information include abstract, author keywords, and the country of the authors. Hence we extracted the titles of all the papers, and searched Web of Science and Scopus to locate the complete BibTex records of the publications. Upon closer inspection of the downloaded BibTex records, we noticed that for some papers the author keywords and abstract of the paper are not present in the BibTex records. To find the missing abstracts, we located the full-text of the corresponding papers and manually extracted the abstract. To find the missing author keywords, the primary approach used was to read the full-text of the papers and try to locate the author keywords section. However, for some papers the list of author keywords was missing from both the full-text of the paper and the BibTex downloaded from Scopus or Web of Science. For these papers we extracted the index terms provided by ACM digital library for each paper and used them as author

ACE '22, February 14–18, 2022, Virtual Event, Australia

ACM ISBN 978-1-4503-9643-1/22/02…$15.00
https://doi.org/10.1145/3511861.3511862

keywords in the BibTex records with a missing author keyword. The Bibliometrics analysis used for this paper was carried out in R using the Bibliometrix package [3].

3 RESULTS

3.1 Main information about the collection of papers

Over the past 22 occurrences of ACE, a total number of 845 individual authors published in ACE. The total number of author appearances in ACE proceedings is 1511, with 103 authors publishing single-authored papers, and 742 authors contributing multi-author papers. A total number of 129 papers are single-authored papers, with 0.64 as document per author ratio, 1.55 as author per document ratio, 2.77 as co-authors per document ratio, and 1.78 as collaboration index. The average citations per year per document is 0.74, with an average citations per document index of 8.77. The total number of keywords identified in the BibTex records of the collection of the papers is 2372 which shows the large diversity of concepts with which ACE papers are associated. Figure 1 represents a visualisation of the countries with greatest number of papers published in ACE, the affiliation of the authors, and the main topics of interest of those authors. The length of the vertical bars of the left field and the middle field of the paper represent the amount of contribution of the countries and their corresponding affiliations respectively. The length of the vertical bars of the right field represents the density of the topics associated to the affiliations and respectively represent the interest of the authors grouped by the countries in those topics. Based on the results of our analysis, Monash University, University of Auckland, University of Technology Sydney, University of Newcastle, and Queensland University of Technology represent the top five affiliations with 44, 34, 32, 31 and 22 papers published in ACE respectively. The countries with the most number of publications in ACE are Australia, New Zealand, United States, Sweden and United Kingdom. To understand ACE authors' level of collaboration among different countries, we created a country collaboration network (see Figure 2). The thickness of the edges in that visualisation show the degree of collaboration measured by the number of papers co-authored by authors from two countries. The size of each node indicates the total number of papers contributed with some author from that country. Through community detection performed by clustering we can see the collaboration network separates into two communities, one centred on the Anglophone countries, the other apparently centred on Scandinavia, though we note that Norway has an apparently independent collaboration network from Sweden and Finland, although this is almost certainly an effect of the small number of Norwegian contributors. A more detailed collaboration network for the affiliations of the corresponding authors of ACE is provided in Figure 3. Again the edge width indicates the number of collaborations between two affiliated institutions, and the node side the total number of contributions with an author affiliated with that institution. Community analysis again splits the network into two communities which are, interestingly, not divided along national lines. The two main contributing countries (Australia and New Zealand) are represented in both communities, however we note that main Scandinavian contributors are together in the same community.

3.2 Analysis of the papers

3.2.1 Most locally cited papers. Table 1 presents statistics concerning the 10 papers with the highest local citation rates within ACE proceedings. Looking at the data collectively, it is interesting to observe the difference in relative local and global citation rates (expressed in the LC/GC Ratio) between the papers, indicating that the relationship between what attracts attention locally and what attracts attention globally is unpredictable. We also observe that the papers attracting the most attention come from the "middle third" of the time-span of the conference. Naturally newer papers take some time to build citations, but it is interesting that the newest paper on this list is from 2012. We note in passing that the first full ERA[1] exercise occurred in 2010.

3.2.2 Most globally cited papers. Table 2 presents information on the 10 papers with the greatest number of total citations. Six of the papers here are also in the top ten most locally cited papers (see Table 1), although the relative ordering differs. We note that the paper most cited globally [18] has considerably more global citations than the paper most cited locally [31]. The changes in ordering suggest at least some difference in the interest in topics between the local and global audiences. It is certainly not clear what differentiates the papers that attract one of either local or global attention. Indeed 5 out of the 8 papers are concerned with related topics concerning novice programmers [7, 11, 13, 23, 24].

3.3 Analysis of the topics

Author keywords present in a paper represent the sort of concepts that relate to the paper. To find out what are the most frequent author keywords for each conference proceeding, we performed a trend topics analysis (see Figure 4). While the major umbrella topics remain relatively steady, it is interesting to observe the shift in foci over the years. Distance education was a consistent topic early in the life of the conference, but faded from view (perhaps to make a sudden comeback presently), user interfaces similarly has fallen from favour. Collaborative learning had a heyday from 2006 to 2012, but has also receded. A general focus on programming seems to be developing with topics such as "code review", "programming exercises" and "programming assignments" coming to the fore (while "computer programming" has remained steadily in view). Naturally some of these changes are a reflection less of change of topic than change in language and nomenclature, with subtleties in the way we refer to topics of interest shifting to phraseology such as "teaching and learning". It is interesting that "students" as a topic is apparently absent from earlier work.

Table 3 reviews the top most frequent keywords appearing in papers published in ACE. "Students" is by far the most frequent, followed by a group of keywords related to education, and finally followed by a group of keywords surrounding programming. This becomes especially interesting when we consider the dynamics of the use of these keywords (see Figure 5). While most keywords exhibit steady growth, retaining approximately the same ordering, "Students" has shown rapid growth since 2004, rising to its current position as most prominent keyword. More recently, "Education Computing" appears to be changing its relate prominence, with a

[1] https://www.arc.gov.au/excellence-research-australia

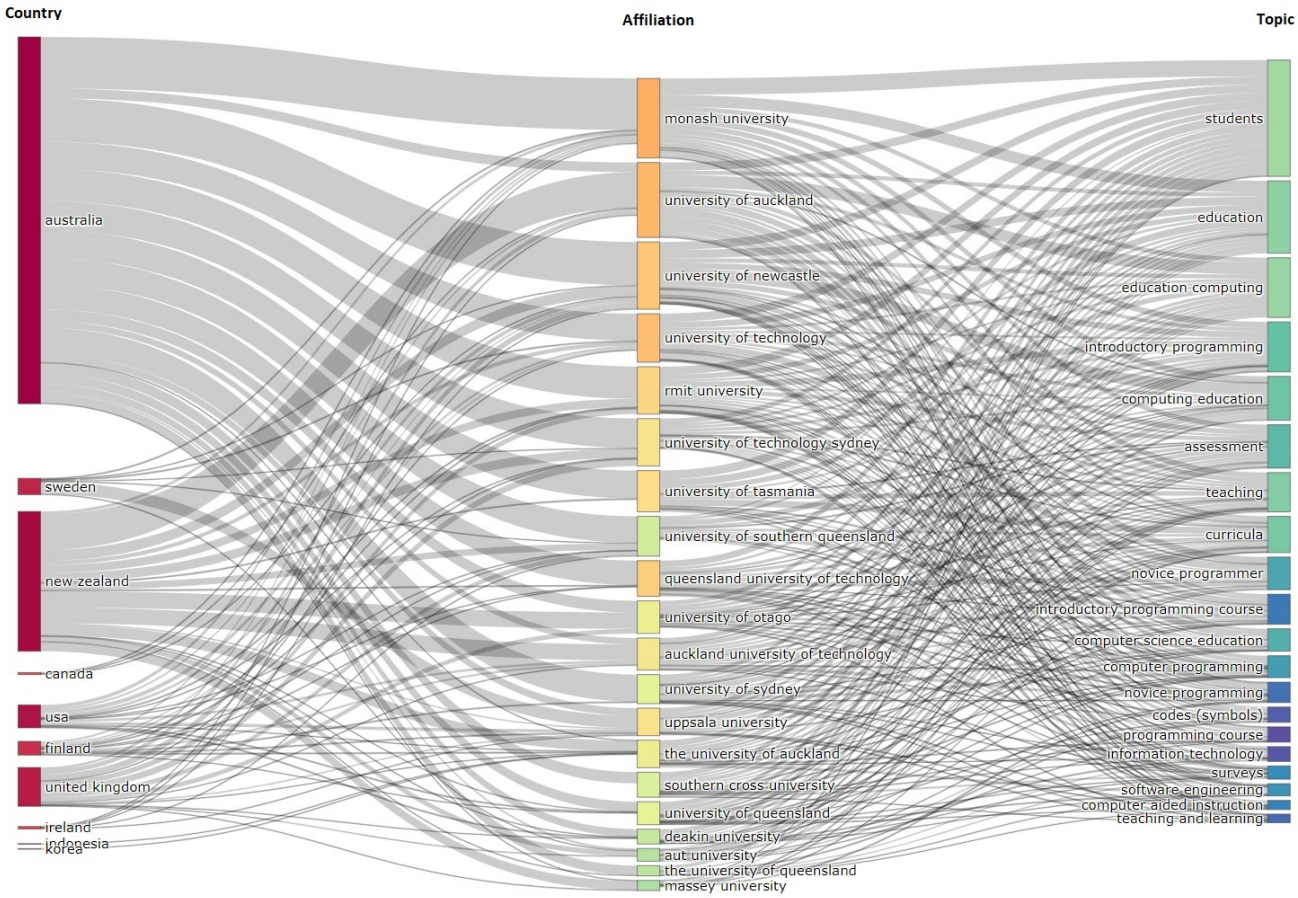

Figure 1: Three-fields plot of the countries, author affiliations, and topics.

Figure 2: ACE author's country collaboration network

change in growth rate since 2017. We note that no keyword (out of the 10 most frequent at least) shows a sign of major decline in use, the changes in frequency over the years is due to increasing rates of use of particular keywords.

We further sought to find out the relationship between the keywords associated to the paper. To do that we used hierarchical clustering method on the keywords of the papers. The result of that analysis is presented in Figure 6. This visualisation provides a categorisation of the keywords into multiple clusters and sub-clusters and is particularly useful to identify the semantic relationships between the keywords in light of their associations to the papers. For instance, it is evident that *CS1* and *assessment* have co-occurred in the papers multiple times which can be interpreted as the examination of how assessment is performed for *CS1* subjects.

Lastly, we aimed to understand the evolution of sort of papers submitted to ACE over time. Therefore, we performed a thematic evolution analysis of all papers published in ACE over two time periods, 1996 to 2009, and 2010 to 2021. Figures 7 and 8 show the results of this analysis. In those Figures, the centrality measures the degree of interaction of a network with other networks. This can be interpreted as a measure of the importance of a theme in

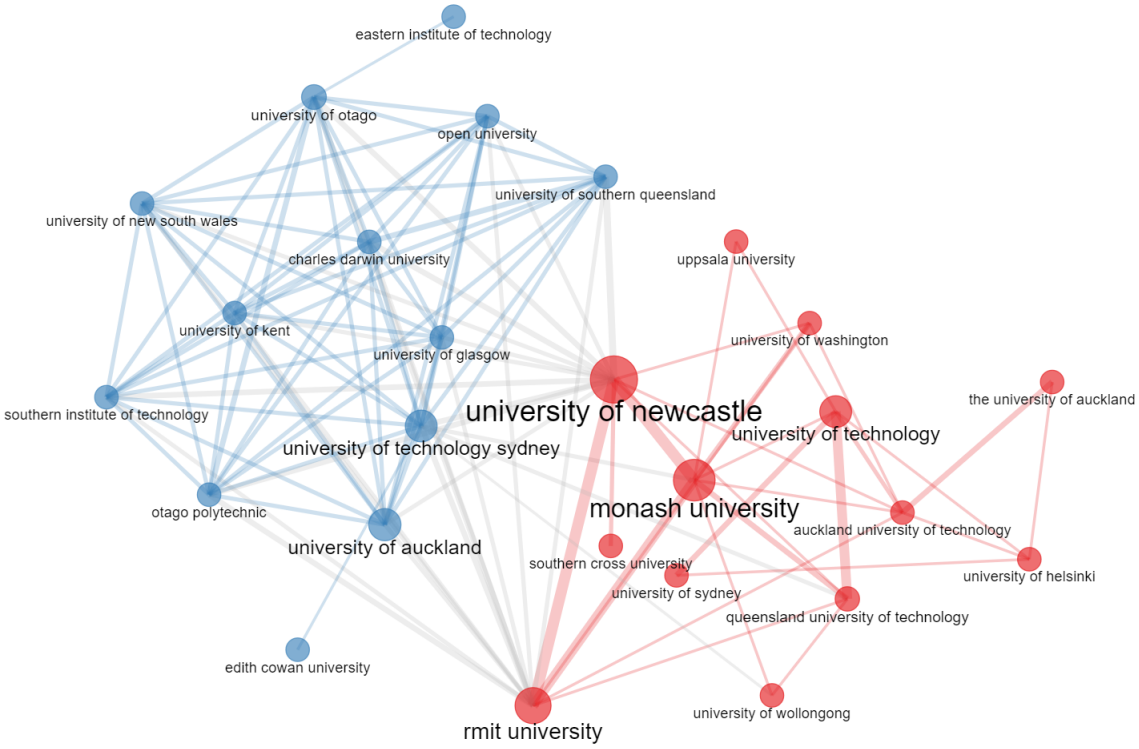

Figure 3: ACE author affiliation collaboration network

Table 1: Most locally cited papers. LC is local citation, GC is global citation.

Title	Year	LC	GC	LC/GC Ratio	Normalized LC	Normalized GC
An Australasian Study Of Reading And Comprehension Skills In Novice Programmers, Using The Bloom And Solo Taxonomies [31]	2006	25	120	20.83	12.5	6.24
Concrete And Other Neo-piagetian Forms Of Reasoning In The Novice Programmer [14]	2011	10	65	15.38	8	6.22
Parson's Programming Puzzles: A Fun And Effective Learning Tool For First Programming Courses [18]	2006	9	161	5.59	4.5	8.37
Bloom's Taxonomy For Cs Assessment [29]	2008	9	116	7.76	4.75	5.96
Introductory Programming: Examining The Exams [7]	2012	8	19	42.11	8.36	2.36
Performance And Progression Of First Year Ict Students [23]	2008	7	12	58.33	3.69	0.62
On Blooming First Year Programming, And Its Blooming Assessment [13]	2000	7	48	14.58	25.2	6.24
Employer Satisfaction With Ict Graduates [12]	2004	7	44	15.91	6.27	3.27
This Course Has A Bloom Rating Of 3.9 [17]	2004	7	56	12.5	6.27	4.17
Predictors Of Success In A First Programming Course [10]	2006	6	54	11.11	3	2.81

the development of the entire research field analysed. The density measures the internal strength of the network and identifies the degree of development of a theme. The analysis quantifies the extant and within ties of keywords with various themes in the dataset [5]. Analysing the keywords from the papers in our dataset using the thematic analysis reveals various topics as per their stage of development and relevance. These figures represent these themes in four quadrants, namely *motor themes*, *niche themes*, *emerging or declining themes*, and *basic and transversal themes* according to their centrality and density rank. The size of each cluster is determined by the

Table 2: Most cited papers. TC is total citation.

Title	Year	TC	TC per year	Normalized TC
Parson's Programming Puzzles: A Fun And Effective Learning Tool For First Programming Courses [18]	2006	161	10.0625	8.36
An Australasian Study Of Reading And Comprehension Skills In Novice Programmers, Using The Bloom And Solo Taxonomies [31]	2006	120	7.5	6.23
Bloom's Taxonomy For Cs Assessment [29]	2008	116	8.2857	5.95
Static Analysis Of Students' Java Programs [30]	2004	75	4.1667	5.57
Concrete And Other Neo-piagetian Forms Of Reasoning In The Novice Programmer [14]	2011	65	5.9091	6.22
The Peerwise System Of Student Contributed Assessment Questions [8]	2008	64	4.5714	3.28
My Program Is Correct But It Doesn't Run: A Preliminary Investigation Of Novice Programmers' Problems [11]	2005	58	3.4118	3.75
A Taxonomic Study Of Novice Programming Summative Assessment [24]	2009	58	4.4615	4.39
This Course Has A Bloom Rating Of 3.9 [17]	2004	56	3.1111	4.16
Predictors Of Success In A First Programming Course [10]	2006	54	3.375	2.80

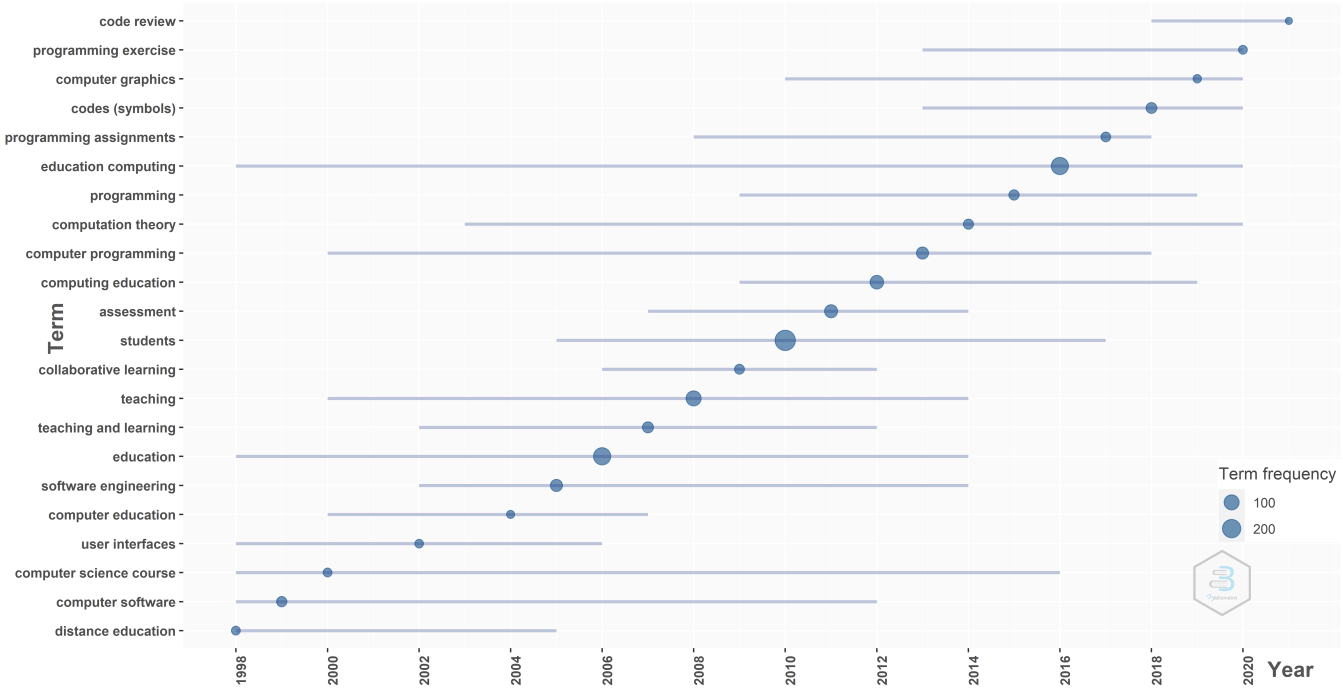

Figure 4: Top Trending Topics within Collection of Publications

number of times the keywords occurred. The upper right quadrant presents the Motor themes; well developed themes that are key to the structure of the research field. The upper left quadrant identifies the Niche themes. These are specialised yet marginal themes with respect to the other themes observed in the entire population of the papers investigated. The lower left quadrant identifies emerging or declining themes which represent the topics which are at the periphery of the research field. Finally the lower right quadrant represents Basic and transversal themes. These themes are regarded as important for the field and are frequently researched. Here we see the same growth in importance of themes such as "Students" that can be observed in the keywords and trend topics and also the considerable increase in relevance of introductory programming as a theme.

3.4 Analysis of the authors

In an attempt to capture the level, frequency and impact of contribution by ACE authors, we first narrowed our consideration to authors with a high rate of contribution to ACE. The top 10 authors by number of ACE publications are given in Table 4. To characterise

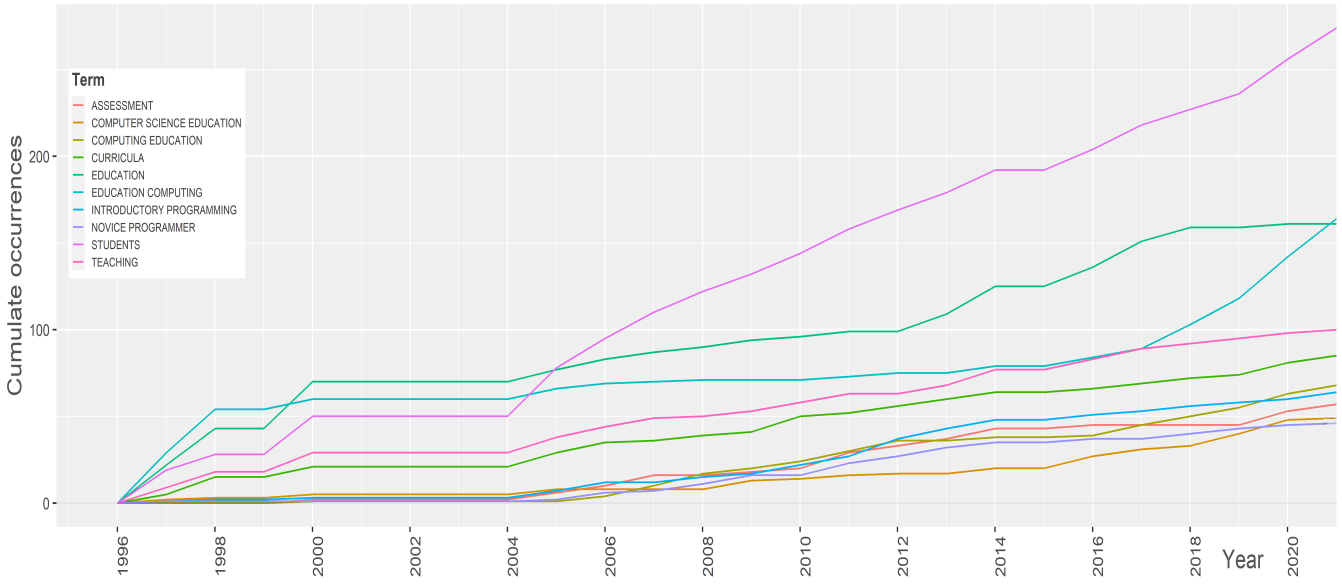

Figure 5: Word Dynamics

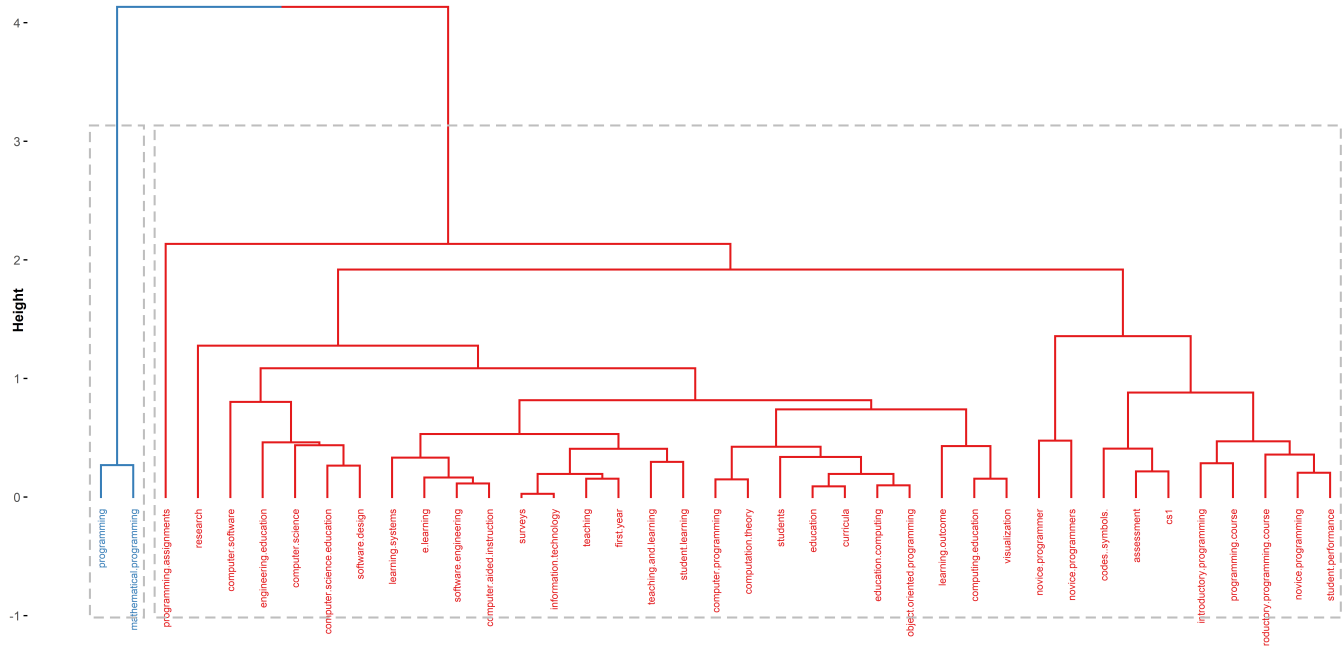

Figure 6: Topic Dendrogram

the contribution of these authors over time, we then generated the author production over time plot which can be found in Figure 10. This gives a picture of the distribution of contributions over time, and also their collective impact. From this we can observe that most authors generate publications in relatively tight groupings (with exceptions), but in contrast the citation of those works occurs relatively steadily over time. Lastly, we looked at which papers ACE authors found most central, indicated by the citation count from ACE papers. The result of that analysis can be found in Table 5. The paper with the highest number of citations in ACE proceedings is the study conducted by Anthony Rubins [21] which represents the *learning edge momentum (LEM) effect* for *CS1*. The exploration of the population of the papers which are most cited by ACE authors is beyond the scope of this study however, a preliminary analysis of

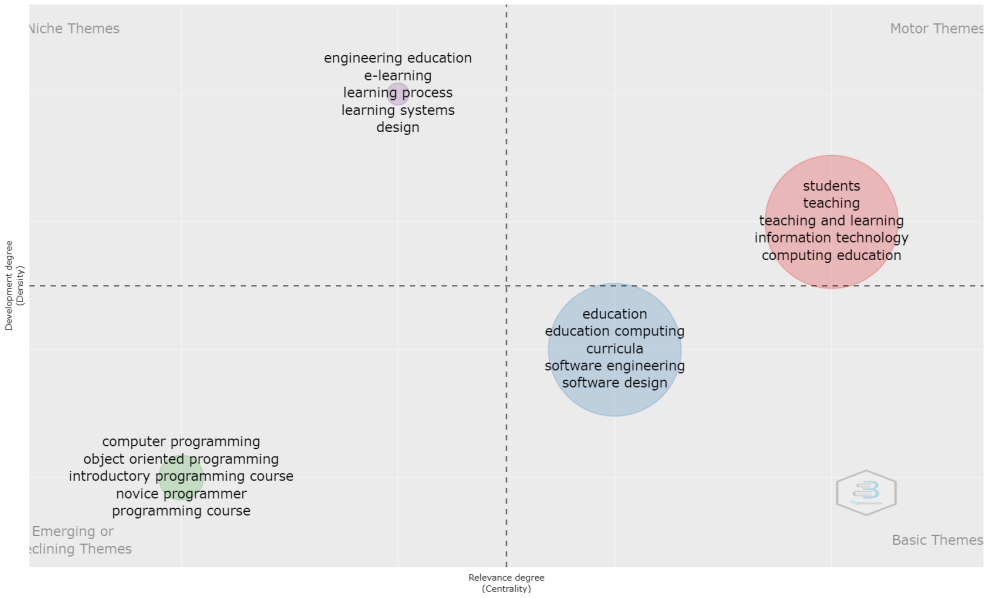

Figure 7: Thematic Evolution before 2009

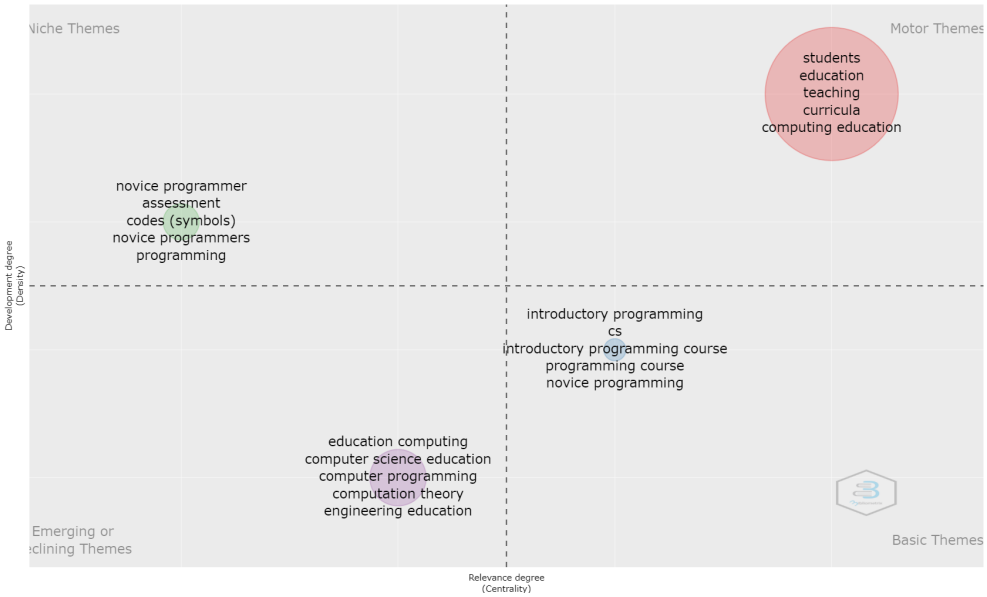

Figure 8: Thematic Evolution from 2009

Figure 9: Thematic evolution over the lifetime of ACE. Figures 7 and 8 show the development (vertical axis) and relevance (horizontal access) of themes in the conference. Figure 7 shows the prominent themes from the period 1996 to 2008 inclusive, Figure 8 shows the prominent themes from the period 2009 to 2021 inclusive.

the abstracts of these papers revealed that majority of these papers are about learning to program.

4 CONCLUSION

In this paper, we deployed a bibliometrics analysis approach to systematically analyse the metadata of all publications of the Australasian Computing Education conference from its inception up to and including the most recent instance of the conference in 2021.

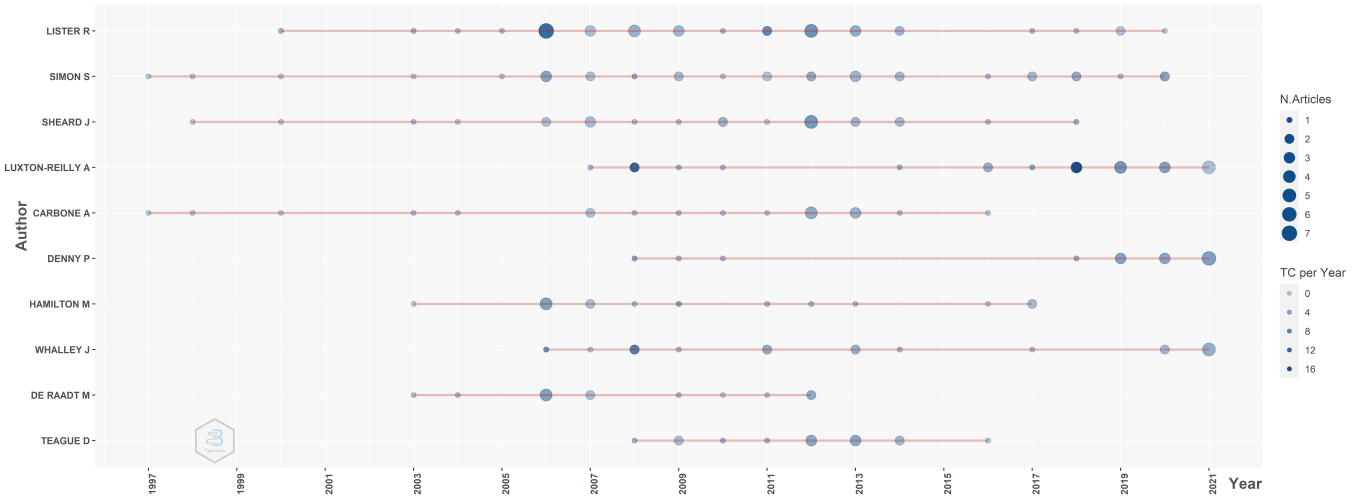

Figure 10: Top Authors Production Over Time

Table 3: Ten highest frequency keywords across ACE papers.

Keyword	Frequency	Percentage
Students	274	17%
Education Computing	164	10%
Educations	161	10%
Teaching	100	6%
Curricula	85	5%
Computing Education	68	4%
Introductory Programming	64	4%
Computer Science Education	49	3%
Novice Programmer	46	3%
Computer Programming	43	3%

Table 4: Most Relevant Authors (Sorted alphabetically)

Author	ACE publication count
A. Carbone	20
M. De Raadt	13
P. Denny	16
M. Hamilton	15
R. Lister	39
A. Luxton-Reilly	24
J. Sheard	25
Simon	31
D. Teague	13
J. Whalley	14

Table 5: Top 5 most cited papers cited by ACE authors

Author	Year	Reference	N. of citations
A. Robins	2010	[21]	7
E. Soloway	1986	[28]	7
J.B. Biggs and K.F. Collis	1982	[4]	6
A. Robins et al.	2003	[22]	6
P. Ramsden	1992	[20]	5
A. Robins et al.	2003	[22]	5
B. Adelson	1984	[1]	4
R. Lister et al.	2004	[15]	4
Deloitte Access Economics	2017	[9]	3
L.W. Anderson et al.	2001	[2]	3

The contribution of this paper is two-fold. First, we demonstrate how using bibliometric analysis can advance our understanding of the nature and evolution of the conference over its history. Second, our results will help the ACE community and in particular the ACE organisers to identify the key topics, papers, authors, and the relationships between these concepts over time. This paper also lays the groundwork for more in-depth examination of a number of aspects of the computing education research field. The shift in topic and theme focus presents an interesting picture of the changing educational landscape and it would be interesting to explore the relationship between how we *talk* about teaching and learning with how we undertake teaching and learning (optimistically assuming such a relationship exists). The underpinnings of collaboration networks would also be interesting to unpick – while collaboration across Anglophone nations is perhaps natural, why do we see little to no collaboration with Asian, African and South American nations? Even large swathes of Europe are surprisingly underrepresented. There are two primary limitations to this study. While using bibliometric analysis can provide useful information, the data preparation step in this process is of crucial importance. In particular, the missing information in the metadata of the papers as well as the representation of the author names in different publication and citation databases (Scopus, Web of Science, ERIC) are among two aspects that might impact this process negatively.

REFERENCES

[1] Beth Adelson. 1984. When novices surpass experts: The difficulty of a task may increase with expertise. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 10, 3 (1984), 483.

[2] Lorin W Anderson and David R Krathwohl. 2001. *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. Longman,.

[3] Massimo Aria and Corrado Cuccurullo. 2017. bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of informetrics* 11, 4 (2017), 959–975.

[4] John B Biggs and Kevin F Collis. 2014. *Evaluating the quality of learning: The SOLO taxonomy (Structure of the Observed Learning Outcome)*. Academic Press.

[5] Michel Callon, Jean-Pierre Courtial, and Francoise Laville. 1991. Co-word analysis as a tool for describing the network of interactions between basic and technological research: The case of polymer chemistry. *Scientometrics* 22, 1 (1991), 155–205.

[6] Angela Carbone, Michael de Raadt, Raymond Lister, Margaret Hamilton, and Judy Sheard. 2008. Classifying computing education papers: process and results. In *Proceedings of the Fourth international Workshop on Computing Education Research*. 161–172.

[7] Donald Chinn, Michael de Raadt, Anne Philpott, Judy Sheard, Mikko-Jussi Laakso, Daryl D'Souza, James Skene, Angela Carbone, Tony Clear, Raymond Lister, et al. 2012. Introductory programming: examining the exams. In *Proceedings of the Fourteenth Australasian Computing Education Conference-Volume 123*. 61–70.

[8] Paul Denny, Andrew Luxton-Reilly, and John Hamer. 2008. The PeerWise system of student contributed assessment questions. In *Proceedings of the tenth conference on Australasian computing education-Volume 78*. Citeseer, 69–74.

[9] Deloitte Access Economics. 2017. Australia's digital pulse: Policy priorities to fuel Australia's digital workforce boom.

[10] Sally Fincher, Anthony Robins, Bob Baker, Quintin Cutts, Patricia Haden, Margaret Hamilton, Marian Petre, Denise Tolhurst, Ilona Box, Michael de Raadt, et al. 2006. Predictors of success in a first programming course. In *Conferences in Research and Practice in Information Technology Series*.

[11] Sandy Garner, Patricia Haden, and Anthony Robins. 2005. My program is correct but it doesn't run: a preliminary investigation of novice programmers' problems. In *Proceedings of the 7th Australasian conference on Computing education-Volume 42*. 173–180.

[12] Dianne Hagan. 2004. Employer satisfaction with ICT graduates. In *Proceedings of the Sixth Australasian Conference on Computing Education-Volume 30*. Citeseer, 119–123.

[13] Raymond Lister. 2000. On blooming first year programming, and its blooming assessment. In *Proceedings of the Australasian conference on Computing education*. 158–162.

[14] Raymond Lister. 2011. Concrete and other neo-Piagetian forms of reasoning in the novice programmer. In *Conferences in research and practice in information technology series*.

[15] Raymond Lister, Elizabeth S Adams, Sue Fitzgerald, William Fone, John Hamer, Morten Lindholm, Robert McCartney, Jan Erik Moström, Kate Sanders, Otto Seppälä, et al. 2004. A multi-national study of reading and tracing skills in novice programmers. *ACM SIGCSE Bulletin* 36, 4 (2004), 119–150.

[16] Raymond Lister and Ilona Box. 2009. A citation analysis of the ICER 2005-07 proceedings. In *Conferences in Research and Practice in Information Technology Series*.

[17] Dave Oliver, Tony Dobele, Myles Greber, and Tim Roberts. 2004. This course has a Bloom Rating of 3.9. In *Proceedings of the Sixth Australasian Conference on Computing Education-Volume 30*. 227–231.

[18] Dale Parsons and Patricia Haden. 2006. Parson's programming puzzles: a fun and effective learning tool for first programming courses. In *Proceedings of the 8th Australasian Conference on Computing Education-Volume 52*. 157–163.

[19] Nonthapat Pulsiri and Ronald Vatananan-Thesenvitz. 2018. Improving systematic literature review with automation and bibliometrics. In *2018 Portland International Conference on Management of Engineering and Technology (PICMET)*. IEEE, 1–8.

[20] Paul Ramsden. 2003. *Learning to teach in higher education*. Routledge.

[21] Anthony Robins. 2010. Learning edge momentum: A new account of outcomes in CS1. *Computer Science Education* 20, 1 (2010), 37–71.

[22] Anthony Robins, Janet Rountree, and Nathan Rountree. 2003. Learning and teaching programming: A review and discussion. *Computer science education* 13, 2 (2003), 137–172.

[23] Judy Sheard, Angela Carbone, Selby Markham, Angas John Hurst, Des Casey, and Chris Avram. 2008. Performance and progression of first year ICT students. In *Proceedings of the tenth conference on Australasian computing education-Volume 78*. 119–127.

[24] Shuhaida Shuhidan, Margaret Hamilton, and Daryl D'Souza. 2009. A taxonomic study of novice programming summative assessment. In *Proceedings of the Eleventh Australasian Conference on Computing Education-Volume 95*. Citeseer, 147–156.

[25] Simon. 2007. A Classification of Recent Australasian Computing Education Publications. *Computer Science Education* 17, 3 (2007), 155–169.

[26] Simon. 2009. Ten years of the australasian computing education conference. *Conferences in Research and Practice in Information Technology Series* 95 (2009), 157–163. https://www.scopus.com/inward/record.uri?eid=2-s2.0-84869141785&partnerID=40&md5=a9ecb4829e12ea1192a2f0f8cfd2d653 cited By 3; Conference of 11th Australasian Computing Education Conference, ACE 2009 ; Conference Date: 20 January 2009 Through 23 January 2009; Conference Code:93142.

[27] Simon. 2020. Twenty-two years of Ace. *ACE 2020 - Proceedings of the 22nd Australasian Computing Education Conference, Held in conjunction with Australasian Computer Science Week* (2020), 203–210. https://doi.org/10.1145/3373165.3373188 cited By 2; Conference of 22nd Australasian Computing Education Conference, ACE 2020, held in conjunction with Australasian Computer Science Week ; Conference Date: 4 February 2020 Through 6 February 2020; Conference Code:157232.

[28] Elliot Soloway. 1986. Learning to program= learning to construct mechanisms and explanations. *Commun. ACM* 29, 9 (1986), 850–858.

[29] Errol Thompson, Andrew Luxton-Reilly, Jacqueline L Whalley, Minjie Hu, and Phil Robbins. 2008. Bloom's taxonomy for CS assessment. In *Proceedings of the tenth conference on Australasian computing education-Volume 78*. 155–161.

[30] Nghi Truong, Paul Roe, and Peter Bancroft. 2004. Static analysis of students' Java programs. In *Proceedings of the Sixth Australasian Conference on Computing Education-Volume 30*. Citeseer, 317–325.

[31] Jacqueline L Whalley, Raymond Lister, Errol Thompson, Tony Clear, Phil Robbins, PK Ajith Kumar, and Christine Prasad. 2006. An Australasian study of reading and comprehension skills in novice programmers, using the Bloom and SOLO taxonomies. In *Conferences in Research and Practice in Information Technology Series*.