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A Picture of the Growing ICER Community

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ABSTRACT

This bibliometric study examines the authorship of the papers presented at ICER since the conference began in 2005. It finds that the pattern of authorship complies well with Lotka's law, an accepted model of author distribution within a discipline. ICER's most prolific authors are identified and their contributions quantified, along with measures of the collaborations between authors. New authors are found to be joining the community at a steady rate, some beginning as co-authors with established community members and some joining alone or with other new authors. The analysis extends to the contributions from different countries. The conclusion is that the community of ICER authors is truly international, has a solid core around which excellent growth is evident, displays strong collaboration, and has at least one of the characteristics of a full-fledged discipline.

1. INTRODUCTION

Where do ICER's authors come from? How many papers do individual authors write? How many authors contribute to individual papers? What are the patterns of collaboration? To answer these and related questions, a brief bibliometric study has been conducted of all the papers accepted to ICER over its eleven-year history.

Bibliometric analysis of this sort is fairly common in the library sciences but not particularly widespread in other areas. Nevertheless, it has been applied to publications in discipline-based educational research, such as science education [11] and engineering education [13, 14]. Within computing education it has featured briefly in papers by Simon and colleagues [8, 10], but there do not appear to be any papers dedicated to the topic. It is therefore unusual and perhaps quirky, but it has merit as the computing education conference equivalent of genealogical research – it helps us to understand who we are ('we' in this case being the ICER authors) and where we have come from. It thus strengthens the notion of the computing education community as a community and not just a set of authors who happen to publish in the same journals and conferences.

Bibliometrics is the mathematical and/or statistical study of publications. There have been at least three other bibliometric studies of ICER, examining very different aspects of the conference.

Lister and Box [2] conducted a citation analysis of the papers from the first three years of ICER; that is, an analysis of the books, journals, and conferences that are cited in ICER papers. Having already conducted similar analysis of both the SIGCSE Technical Symposium and the Australasian Computing Education Conference, they were able to discern a number of ways in which ICER differed from these other conferences. ICER papers tended to cite a greater variety of conferences and a greater variety of journals, and to focus more on the literature of students and learning rather than on syllabic content.

Malmi et al [3] classified papers according to a system previously applied to papers in various areas of computing, and concluded that ICER papers have "more in common with research in information systems than with that in computer science or software engineering".

Miró Juliá et al [4] studied the collaboration networks among authors in ICER, in six computing research conferences, and in six computing education conferences. They concluded that ICER did not sit easily with either the computing research conferences or the computing education conferences, but displayed some of the characteristics of each.

All three of these studies conclude that ICER is unlike whichever other publication venues they looked at. This leads inevitably to the question of just what ICER *is* like. This paper sets out to answer that question by examining the authorship patterns of ICER over its first eleven years.

2. A BRIEF HISTORY OF ICER

SIGCSE, the ACM's Special Interest Group on Computer Science Education, has a long history of running computing education conferences. In 2005 ICER became the third SIGCSE conference, joining the SIGCSE Technical Symposium, which is held in the US early each year, and ITiCSE, which is held in various other countries in the middle of each year. Both SIGCSE and ITiCSE are computing education conferences, but ICER was designed to be something different: a computing education *research* conference. Perhaps the most common type of paper at SIGCSE and ITiCSE [9] is the experience report, also known as the Marco Polo paper ('I went there and I saw this') [12] or Genesis paper ('and he saw what he had made, and it was good') [9]: a report on a technique that has been tried in the classroom, or a piece of software that has been developed for classroom use, but with no clear research component. ICER was intended to be a venue at which only clear and unequivocal research was presented.

Table 1: Summary of the eleven offerings of ICER

ICER	Location	Program chairs	Submitted	Accepted	Accept rate
2005	Seattle, USA	Richard Anderson, Sally Fincher, Mark Guzdial	35	16	46%
2006	Canterbury, UK	Richard Anderson, Sally Fincher, Mark Guzdial	23	13	57%
2007	Atlanta, USA	Richard Anderson, Sally Fincher, Mark Guzdial	24	14	58%
2008	Sydney, Australia	Raymond Lister, Michael Caspersen, Mike Clancy	46	16	35%
2009	Berkeley, USA	Mike Clancy, Michael Caspersen, Raymond Lister	24	13	54%
2010	Aarhus, Denmark	Michael Caspersen, Mike Clancy, Kathryn Sanders	38	12	32%
2011	Providence, USA	Michael Caspersen, Alison Clear, Kate Sanders	47	18	38%
2012	Auckland, NZ	Alison Clear, Kate Sanders, Beth Simon	54	21	39%
2013	San Diego, USA	Beth Simon, Alison Clear, Quintin Cutts	70	22	31%
2014	Glasgow, UK	Quintin Cutts, Beth Simon, Brian Dorn	69	17	25%
2015	Omaha, USA	Brian Dorn, Quintin Cutts, Judy Sheard	96	25	26%

The locations of the ICER conferences currently form a clear repeating pattern: USA, Europe, USA, Australasia.

From the outset, ICER has had three program chairs each year. The first three offerings were led by the ‘triumvirate’ of Richard Anderson, Sally Fincher, and Mark Guzdial. Three years later their place was taken by a second triumvirate of Raymond Lister, Michael Caspersen, and Mike Clancy; but during their term a change was made to a rolling system whereby each year one chair would depart and one would be appointed. This system, which has persisted since 2010, has the advantage that every year there are experienced chairs to guide the new one. An interesting consequence of the change from fixed to rolling chairs is that one chair, Michael Caspersen, served for four years rather than three. As he is likely to be the only person ever to chair ICER for four consecutive years, on his retirement from the position he was symbolically presented with an engraved (window) de-icer.

In its second and third years, and again in its fifth, ICER had substantially fewer paper submissions than in the first and intervening years. In those years the paper acceptance rate was over 50%. In more recent years submission numbers have been consistently higher, and the acceptance rate has ranged between 25% and 40%. From 2013 onward, two associate chairs have been appointed each year to help with the load of making decisions on each paper.

Table 1 summarises the eleven ICER conferences that have been held to date, listing for each conference its location, program chairs, number of submissions, number of accepted papers, and acceptance rate.

For its first six years ICER called for and accepted only a single type of paper, the *research paper*. From 2011 to 2013 the conference also accepted *discussion papers*, shorter papers that were in some respect not full research papers, but that were considered to be worth airing and discussing at the conference. In addition, workshops on various research topics have often been co-located with ICER, and there has been a co-located doctoral consortium since 2008.

ICER’s program committee has grown steadily, if not monotonically, from 19 members in 2005 to 61 in 2015. Only ten

of the original 19 were on the committee in 2015, so there have clearly been many new members over the years.

3. PAPERS

In the eleven years since ICER began, the conference has accepted and published 170 research papers and 17 discussion papers. The number of discussion papers is so small that they cannot be usefully analysed as a group, so for the purposes of this analysis the research and discussion papers will be considered together, a total of 187 papers.

4. AUTHORS AND CONTRIBUTIONS

Counting the names immediately below the titles of all of the 187 papers gives a total of 598 authors. However, this is not the same as the number of distinct authors, as many authors have contributed to more than a single ICER paper. We shall instead refer to this quantity as the number of *author contributions*, defining an author contribution as one author’s contribution to one paper. The total of 598 author contributions to 187 papers means that the papers have an average of about 3.2 authors each.

In determining the number of distinct authors, one must be aware that authors can change their names between papers, or can use different forms of the same name; and that it is possible for different authors to have the same name. By way of illustration one need look no further than Table 1: the program chairs included Kathryn Sanders in 2010 and Kate Sanders, the same person, in 2011. A simple text comparison of author names must therefore be informed by additional information such as the authors’ institutions and the groups, if any, in which they tend to work. Such a count of the ICER authors finds that the 187 papers have 312 distinct authors.

4.1 Persistent authors

Only two authors, Robert McCartney and Kate Sanders, have had papers at every ICER since 2005. Mark Guzdial has had papers at ten, Beth Simon at nine, and Raymond Lister at eight. Table 2 shows the 31 authors who have had papers at four or more ICERs.

Table 2: authors with papers accepted at specified number of ICERs

ICERs	Authors	Names
11	2	Robert McCartney, Kate Sanders
10	1	Mark Guzdial
9	1	Beth Simon
8	1	Raymond Lister
7	4	Anna Eckerdal, Sally Fincher, Lynda Thomas, Carol Zander
6	5	Brian Dorn, Brian Hanks, Päivi Kinnunen, Briana Morrison, Carsten Schulte
5	7	Jonas Boustedt, Colleen Lewis, Lauri Malmi, Jan Erik Moström, Laurie Murphy, Judy Sheard, Simon
4	10	Jens Bennedsen, Neil Brown, Stephen H Edwards, Sue Fitzgerald, Michael Hewner, Christopher D Hundhausen, Matthew C Jadud, Gary Lewandowski, Renée McCauley, Josh Tenenberg
3	21	...
2	45	...
1	215	...

4.2 Prolific authors

Which authors have had most papers published at ICER? The authors listed in the preceding section are clearly in consideration, but the number of ICERs at which an author has had papers is not the same as the number of ICER papers by that author. More than 20 authors have had two papers at the same ICER; Robert McCartney, Mark Guzdial, Lynda Thomas, and Simon have each had three papers at a single ICER; and Beth Simon co-authored three papers at ICER 2008 and four at ICER 2011.

There are a number of different ways of quantifying an author's contribution to a paper [1]. With *complete counting*, each author of a paper is given a count of 1 for that paper, regardless of the number of authors. If a paper has four authors, each of the four will be given a count of 1, and the paper will register four contributions. In *complete-normalised counting*, on the other hand, the paper itself is given a count of 1, which is then divided equally among the authors. If a paper has four authors, each of the four will be given a count of 0.25.

Each system has its merits and its drawbacks. Complete-normalised counting acknowledges the shared load of a joint paper, but at the same time it could be seen as devaluing collaboration by giving the authors of a two-author paper only half the credit that either would have earned by writing the paper alone. I have previously argued the importance of collaboration in computing education research [7], suggesting that broader collaboration "might indicate a greater engagement with the computing education community, and will often give more confidence in the generalisability of results". The analysis in this paper will therefore place more emphasis on complete counting, but will acknowledge the differences between it and complete-normalised counting.

Table 3 identifies the 20 authors who have contributed six or more papers to ICER, ranked by complete count. With 18 papers, Beth Simon from the USA is the clear leader.

Table 3: High-contributing authors ranked by complete count (CC), also showing complete-normalised count (CNC) and rank according to CNC

CC	Author	Country	CNC	CNC rank
18	Beth Simon	USA	5.3	2
16	Robert McCartney	USA	3.2	4
14	Mark Guzdial	USA	6.3	1
	Kate Sanders	USA	2.6	9
10	Raymond Lister	Australia	2.6	10
	Lynda Thomas	UK	1.8	18
9	Carol Zander	USA	1.5	28
8	Sally Fincher	UK	2.8	8
	Simon	Australia	1.5	24
7	Brian Hanks	USA	2.4	12
	Briana Morrison	USA	1.7	19
	Anna Eckerdal	Sweden	1.5	27
6	Colleen Lewis	USA	3.5	3
	Brian Dorn	USA	3.2	5
	Carsten Schulte	Germany	3.1	6
	Päivi Kinnunen	Finland	2.6	10
	Jonas Boustedt	Sweden	1.8	16
	Lauri Malmi	Finland	1.8	17
	Judy Sheard	Australia	0.9	51
	Jan Erik Moström	Sweden	0.9	53

The rightmost two columns of table 3 show the complete-normalised counts of these high-contributing authors and their ranks according to that count. In the CNC ranking, Mark Guzdial takes the lead from Beth Simon, because his 14 papers were shared among fewer authors than her 18 papers. Kate Sanders, ranked equal third by CC with 14 papers, drops with CNC to ninth place – displaced by authors who have contributed fewer papers, but with fewer co-authors, such as Colleen Lewis (6 papers, CNC 3.5), Brian Dorn (6 papers, CNC 3.2), and Michael Hewner (4 papers, CNC 3.0). Other substantial differences in ranking can be found by examining the rightmost column of table 3.

It is important to repeat that each of these counting systems has its merits and its drawbacks. A high complete count clearly indicates involvement in a large number of papers, whereas a high complete-normalised count indicates a smaller number of co-authors, and thus possibly a greater contribution to each paper. But of course it is a worthy achievement to be ranked in the top couple of dozen by either system.

4.3 Lotka's law

Lotka's law of author productivity [5] encapsulates the empirical observation that in a sufficiently large list of published papers within a discipline, 60% of authors will contribute to only one paper, 15% to two papers, 7% to three papers, and so on. More precisely, given a total pool of A authors, the number of authors A_n contributing to n papers will be CA/n^p , where C and p are constants that vary according to the discipline but are generally expected to be close to 60% and 2 respectively. Although this is not the most rigorous approach, C can be trivially estimated from the case where $n=1$, that is, the proportion of authors contributing to just one paper; for ICER this estimate gives a value of 68.6%, quite close to the generally quoted 60%. Nicholls [5], having validated Lotka's law on multiple diverse data sets, suggests that

Table 4: Observed and predicted numbers of authors contributing to specified numbers of papers, using Lotka's law with $C=68.6\%$ and $p=2.2$

Contributions	Authors Observed	Authors Predicted
1	214	214
2	42	47
3	22	19
4	12	10
5	2	6
6	8	4
7	3	3
8	2	2
9	1	2
10	2	1
11	0	1
12	0	1
13	0	1
14	2	1
15	0	1
16	1	0
17	0	0
18	1	0

values of 71% to 81% are more realistic than 60%, in which case ICER is very much at the low end of the range. The conclusion is that ICER has about the expected number of authors who have contributed only one paper, and perhaps even fewer than expected: authors tend to come back to ICER.

Table 4 shows the observed numbers of authors contributing to specified numbers of papers, alongside the numbers predicted by Lotka's law with the power constant p set at 2.2 to give a reasonable match with the observed counts for two, three, and four contributions.

What table 4 tells us is that the authors of ICER form a good fit with the power law proposed by Lotka for a sufficiently large list of published papers within a discipline. That is, the eleven years of ICER appear to constitute a sufficiently large list of published papers, and the ICER community displays the publishing hallmarks of a research discipline. This is not a given: a similar analysis of the ITiCSE conference [9] shows a very poor fit with Lotka's law, with 79.5% of authors contributing to just one paper each.

4.4 Sociable authors

Section 4.2 mentions some authors who have a high complete count, having contributed to a large number of papers, but a relatively low complete-normalised count, having shared those papers with many co-authors. It is possible to discern multiple papers with effectively the same set of authors, groups of researchers who follow an initial paper with more work and subsequent papers. At the same time there are authors who become involved in multiple projects with different co-researchers, and subsequently accumulate larger sets of co-authors.

Table 5 shows the authors with the greatest number of ICER co-authors. It is interesting that the two highest-ranked, with 32 co-authors each, both come from Australia. However, these authors have not achieved this high collaboration level by working

Table 5: ICER authors with 20 or more ICER co-authors

Raymond Lister, Simon	32
Robert McCartney	28
Sally Fincher	25
Kate Sanders	24
Beth Simon, Briana Morrison	23
Judy Sheard, Stephen H Edwards	22
Lynda Thomas	21
Brian Hanks	20

together all of the time: they have only eleven co-authors in common.

4.5 New authors

Particularly in its early years, ICER was perceived by some as a fairly closed club. How easy is it to join this club, or indeed to break into it?

There are two ways for a new author to join the ICER community: to co-author a paper with one or more continuing authors, authors who have previously had papers accepted to ICER; or to contribute to a paper with no continuing co-authors. If most new authors took the former path, it could be considered that they were joining the community by invitation, which would support the view of the community as closed. Invitation of new members is to be expected – as, for example, when a postgraduate adviser writes a paper in collaboration with a new student – but it should not be the only means of entry to the community.

The situation can be examined by observing, for each year, the number of continuing authors, the number of new authors who have co-authored with continuing authors, and the number of new authors who have not co-authored with continuing authors. These counts are shown in figure 1.

The figure shows that while there is a steady number of continuing authors, some 20-35 each year, they do not form the bulk of the authors. Only in 2009, 2011, and 2014 have the continuing authors outnumbered the new authors, and in those years the margin was small. In all of the other years the new authors have been in the majority; and in all years there is a

Figure 1: Counts of continuing authors and of new authors with and without continuing authors

reasonable proportion of new authors not accompanied by continuing authors.

The papers themselves display a similar trend, following the first three years which were naturally dominated by papers from new authors. In the subsequent eight years, about 40% of ICER papers have had a mix of continuing and new authors, about 30% have had only continuing authors, and about 30% have had only new authors.

These results together show that ICER is by no means a closed club: that a steady stream of new authors join it, both in collaboration with continuing authors and alone or with other new authors.

4.6 Collaboration clusters

In 2012, Miró Juliá et al [4] studied the collaboration networks among authors in six computing education conferences, six computing research conferences, and ICER. They observed the expected clusters of authors formed by adding transitivity to co-authorship: if A has written a paper with B and a paper with C and D, and C has written another paper with E, F, and G, then all seven of these authors will be in the same cluster. They noted further that every collaboration network will include one ‘giant component’ comprising a large percentage of its members.

In 2012, ICER’s giant component comprised just 49% of its authors, which is above the 14%-46% seen in computing education conferences and at the low end of the 43%-83% seen in computing research conferences [4]. When the ICER analysis is extended to include the subsequent four years, the giant component becomes 55%, which fits more comfortably in the range for computing research conferences. It clearly takes some years to grow a giant component to the point where it is reasonably stable. The 2012 analysis incorporated all seven years of ICER to that point, but 12-16 years of the other conferences; perhaps the analysis was conducted too early in the life of ICER, and perhaps ICER’s network characteristics are still stabilising.

Figure 2: Percentages of Merge, Extend, Internal, and New papers for computing education conferences, computing research conferences, ICER to 2011, and ICER to 2015. All values except those represented by B are from Miró Juliá et al [4].

Miró Juliá et al [4] defined four groups of papers according to the effect the papers have on the collaboration network. *Merge* papers include authors from two distinct clusters, and so merge those two into a single cluster. If there are also co-authors who are new to the network, they are added to the merged cluster. In *Extend* papers, existing authors from a single cluster join with new authors, thus adding new members to the cluster of the existing authors. *Internal* papers are written by existing authors who are already in the same cluster, and so change nothing in the network. *New* papers are written by authors all of whom are new to the network, and so generate a new cluster.

The 2012 analysis includes the proportions of Merge, Extend, Internal, and New papers in the conferences under consideration. Figure 2 shows the ranges of these values for computing education conferences, for computing research conferences, and for ICER to 2011 [4]. The values for ICER have been recomputed to incorporate the subsequent four years, and are shown on the figure as the points marked B. Most noteworthy is that since 2012 the proportions of Merge and Internal papers at ICER have moved beyond the range of those proportions at computing education conferences and at computing research conferences. This means that existing ICER authors are more likely to have further papers accepted to ICER, either with the same co-authors (Internal papers) or with new co-authors who are already in the network (Merge papers). This persistence of ICER authors is what ensures the good fit with Lotka’s law discussed in section 4.3.

5. PAPERS AND COUNTRIES OF ORIGIN

If all of a paper’s authors come from the same country, that can be designated as the country of origin of the paper. If the authors come from two or more countries, the paper can be called multinational. Of the 187 papers being examined, 47 are multinational: 34 with authors from two countries, nine spanning three countries, two spanning four countries, and two papers with authors from five countries.

There are at least four ways to count a country’s share of a multinational paper [1]. This analysis uses *whole-normalised counting*, in which each distinct country found in a paper’s author list takes an equal share of the unit count for that paper. A paper with three authors from Denmark and one from New Zealand will count as 0.5 for each country, not 0.75 for Denmark and 0.25 for New Zealand. While the different schemes produce somewhat different counts, this one was chosen for its relative simplicity.

Table 6 shows the number of papers from each country. Note that with rounding of the fractional counts, the sum of the counts in table 6 is slightly less than the actual number of papers.

Table 6: Number of papers from each country (rounding errors from fractional papers are significant)

USA	106.5	Ireland	4.0
UK	17.2	Denmark	3.5
Finland	12.8	New Zealand	3.3
Australia	12.0	India	1.0
Germany	8.2	Italy	1.0
Israel	5.5	Philippines	1.0
Canada	5.1	Spain	1.0
Sweden	4.8	Russia	0.2

Far more papers have come from the USA than from any other country. From Europe the standouts are the UK, Finland, and Germany. Away from North America and Europe, Australia has produced the highest number of papers.

There are many factors that would influence a country's contribution to ICER, among them being the proportion of academics who readily speak and write English, the proportion of the population who undertake post-secondary education, and the availability of funding for travel to conferences. These factors are not easy to quantify, but one that is relatively easy is the country's population. Table 7 displays the same paper numbers as table 6, but ranked by the number of ICER papers per hundred thousand of population.

Finland is the outstanding leader by this criterion, with Ireland, Israel, and New Zealand leading the remaining countries.

6. BREADTH OF COLLABORATION

The average of 3.2 authors per paper, mentioned at the beginning of section 4, suggests a great deal of collaboration. In this section we shall consider aspects of that collaboration.

A paper from 2008, the fourth year of ICER, holds the record for the greatest number of authors. Entitled *DCER: Sharing empirical computer science education data*, it was written by 14 authors from the USA, Sweden, the UK, and Canada [6].

Collaboration in academic publishing is generally reckoned to be a good thing, and collaboration on ICER papers could be regarded as one measure of the strength of the computing education research community. No collaboration at all can be inferred from a paper with a single author. Several authors at the same institution form a next level of collaboration, and it is probably fair to say that several authors at different institutions constitute a greater depth of involvement with the computing education research community. Perhaps arbitrarily, this analysis ranks multinational contributions higher still, regardless of the number of institutions involved. Collaborations between educational institutions and industry are also counted as multi-institutional or

multinational as appropriate.

Figure 3 shows the number of papers in each of the categories of collaboration mentioned above. It is pleasing that the biggest single category is not single authors, as might be expected, but multiple authors within a single institution, which has more than three times as many papers as the single-author category. However, half of the papers entail collaborations between institutions, and half of those are multinational collaborations. Collaboration is strongly in evidence, and a great deal of that collaboration is between researchers at multiple institutions.

One figure measured by Miró Juliá et al [4] is the average number of collaborators per author. In 2012 this average was 3.31 for ICER, above the 1.59-3.11 found in computing education conferences and near the top of the range of 1.7-3.6 for computing research conferences. When the subsequent four years of ICER are included, the average climbs to 4.73, well above all of the 2012 measures [4]. This is further confirmation that ICER authors are a highly collaborative group.

7. DISCUSSION

This analysis contributes to a picture of the ICER authorship, a picture that will help members of the computing education community to better know and understand that community.

The community of ICER authors appears to conform well to Lotka's empirical description of publication within a discipline. The proportion of authors contributing to just one paper is at the low end of the scale, and the exponent of the power law is reasonably low, indicating that many authors contribute to high numbers of papers. ICER appears to be in a reasonable steady state, with authorship patterns very much like those that would be expected of a complete research discipline.

There is evidence of strong collaboration among ICER authors, both within and between institutions, adding to the perception that the authors of ICER papers are a community rather than a collection of individuals with a shared interest.

The steady influx of new authors is also an excellent sign, showing clear growth in the community. The fact that these new authors appear in more or less equal numbers with established ICER authors on the one hand, and in papers written completely

Table 7: Papers per 100 thousand of population

Country	Papers	Pop (million)	Papers/100 K
Finland	12.8	5.5	23.2
Ireland	4.0	4.7	8.5
New Zealand	3.3	4.6	7.2
Israel	5.5	8.2	6.7
Denmark	3.5	5.7	6.1
Australia	12.0	24.3	5.0
Sweden	4.8	9.9	4.8
USA	106.5	324.1	3.3
UK	17.2	65.1	2.6
Canada	5.1	36.3	1.4
Germany	8.2	80.7	1.0
Spain	1.0	46.1	0.2
Italy	1.0	59.8	0.2
Philippines	1.0	102.3	0.1
Russia	0.2	143.4	0.01
India	1.0	1326.8	0.01

Figure 3: Papers at each level of collaboration

by new authors on the other, illustrates that many of the existing authors are doing a good job of bringing new members to the community, but that this is by no means the only way for a new author to enter the community.

In conclusion, ICER papers display an authorship pattern that has been described as characterising a complete discipline. There is a steady flow of new authors, whether mentored by continuing authors or in papers with only new authors. There is strong evidence of collaboration, both within and between institutions. Taken together, these findings portray the ICER authorship as a vibrant international community with strong bonds, good collaboration, and welcoming of new membership.

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