Enhancing Student Achievement in Mathematics: Identifying the Needs of Rural and Regional Teachers in Australia

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This paper presents results from a survey of secondary mathematics teachers in rural, regional and metropolitan schools across Australia. The purpose of the survey was to compare the major needs of teachers in relation to the attraction and retention of qualified staff, professional development, availability of material resources and support personnel, and the accessibility of a range of student learning opportunities across the three geographical areas. Although differences emerged for some of these factors, the most significant findings were identified in schools with Indigenous populations of greater than 20%.

A review of the 2003 Programme for International Student Assessment (PISA) results indicates that Australian students achieved comparably with a mean of 525 points to the OECD mean of 500 points, with similar results emerging for PISA 2000. However, when these results are deconstructed further, variations in student achievement across geographical divisions are identifiable. Table 1 presents data for PISA 2003 and illustrates that the mean score for students in remote schools for scientific and mathematical literacy was below the international mean of 500. Further, the standard error bars demonstrate that Australian students in metropolitan schools significantly outperformed ($p < 0.05$) those in provincial schools, who in turn had a higher mean achievement than students in remote schools (Thomson, Cresswell, & DeBortoli, 2004).

Table 1
Means and Standard Errors Across Location of Schools for PISA 2003

Geographic Location	*Mathematical Literacy*		*Scientific Literacy*		*Problem Solving*	
	Mean	*SE*	*Mean*	*SE*	*Mean*	*SE*
Metropolitan	528	2.5	529	2.6	533	2.2
Provincial	515	4.4	516	4.2	522	4.4
Remote	493	9.6	489	6.8	503	8.4

(Source: Thomson, Cresswell, & De Bortoli, 2004)

Further evidence of the gap between student achievement across geographical regions is provided from the National Numeracy Benchmarks, which represent agreed minimal standards for numeracy at particular year levels. Figure 1 identifies the percentages of students in Years 3, 5 and 7 across geographical locations in Australia achieving these standards in 2004. Clearly, there are differences between the achievement of students with particularly lower numbers of students in Remote and Very Remote schools achieving the benchmarks.

The factors driving this geographical divide in mathematics have not been explored to any great extent although studies on rural education (Roberts, 2005; Vinson, 2002) have identified several areas for investigation, including the attraction and retention of teachers, accessibility to professional development, provision of adequate teaching resources

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(Cresswell & Underwood, 2004; Vinson, 2002), and the provision of learning opportunities for students.

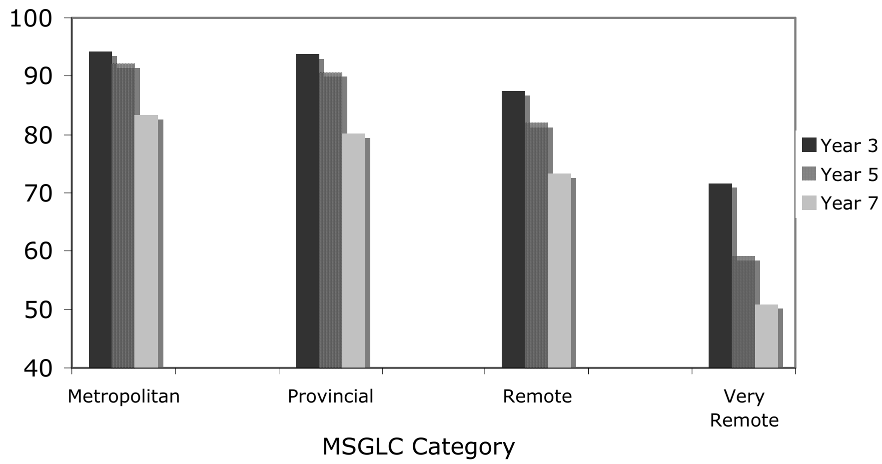

Figure 1. Percentages of Year 3, 5, and 7 students achieving the National Numeracy Benchmarks in 2004 across geographical locations (MCEETYA, 2006).

Clearly, a key factor when considering these research studies is the impact of socio-economic status. Williams (2005) reported that much of the rural-urban variation in the mathematics results for PISA 2000 could be explained by the socio-economic backgrounds of students and schools in the different regions. Importantly, this is not just the case in Australia with many international studies recognising socio-economic status as a confounding variable (Canadian Council on Learning, 2006; Howley, 2003) when investigating student achievement in this manner.

To explore the issues impacting secondary mathematics, science and ICT teachers in rural and regional, a National Survey was conducted in 2005. This paper discusses the findings of this survey (Lyons, Cooksey, Panizzon, Parnell, & Pegg, 2006) as it related to mathematics teachers.

Method

The National Survey consisted of five questionnaire surveys designed for primary teachers, secondary science, ICT and mathematics teachers, and parents. Each of the teacher surveys sought views about the difficulties in attracting and retaining qualified teachers, the degree of access to professional development, the material resources, and support personnel available with each school context, along with student accessibility to a range of learning opportunities.

Definitions of Rural and Metropolitan

Schools in the study were categorised according to the MCEETYA Schools Geographic Location Classification (MSGLC), which considers population size and accessibility to a range of facilities and services. The MSGLC has four main categories of location: Metropolitan Areas, Provincial Cities, Provincial Areas, and Remote Areas (Jones, 2004). Table 2 provides details regarding the category criteria.

Research Sample

Mathematics teacher surveys were distributed to 1998 secondary departments, including all provincial and remote secondary departments across Australia along with a stratified random sample of 20% (N=291) of metropolitan secondary departments. Teachers were invited to complete the survey online if they preferred using an identifiable code for the school. Responses were received from 547 secondary mathematics teachers representing Government, Catholic and Independent schools (Table 2).

Table 2
Secondary Mathematics Teacher Respondents by MSGLC Category

	Main MSGLC categories				
	Metropolitan Area	*Provincial City*	*Provincial Area*	*Remote Area*	
Criteria	Major cities pop. ≥ 100 000	Cities with pop. 25 000 – 99 999	Pop. < 25 000 and ARIA* Plus score ≤ 5.92	Pop. < 25 000 and ARIA* Plus score > 5.92	*Total*
Number of mathematics respondents (%)	142 (26%)	132 (24.1%)	240 (43.9%)	33 (6%)	547 (100%)
Total teacher respondents (%)	580 (19.7%)	661 (22.5%)	1425 (48.5%)	274 (9.3%)	2940 (100%)

* ARIA = Accessibility and Remoteness Index of Australia (ARIA). Locations are given a value for each of these criteria between 0-15 based on road distance to the nearest town or service centre.

Data Analysis

The analytical strategies altered depending on the research questions and the characteristics of the data sets. For example, categorical data (teacher background information) were explored through frequency analyses, cross-tabulations, and chi-squared significance tests. To minimise inaccurate claims about significance the convention of p = 0.05 was reset to a much stricter level of p = 0.001. However, statistical tests achieving a level of significance of p = 0.01 were identified as suggestive and worthy of further exploration.

Rating importance and availability of need items. The mathematics teacher survey consisted of two Likert scales with teachers rating the *Importance* and *Availability* of a range of items related to professional development opportunities, resources, and learning experiences in their school. The Importance scales ranged from 1 (Not at all Important) to 5 (Extremely Important) whereas the Availability scales ranged from 1 (Never Available) to 4 (Always Available). The Importance and Availability ratings were then combined to produce an "Unmet Need" scores, where higher values indicated a greater unmet need for the resource or opportunity. This score was calculated using the transformation "need" = I x (5 – A), where 'I' was the Importance rating and 'A' the Availability rating. An item considered extremely important (5) but unavailable (1) generated the highest unmet need score (20). Alternatively, items that were unimportant and always available attracted the lowest score (1). More detail about this approach is found in the full technical report (Lyons et al., 2006).

Principal components and multivariate analysis of covariance (MANCOVA). As the mathematics teacher survey contained several items addressing an overarching theme (e.g., professional development) Principal Components analysis was undertaken to identify subsets of items measuring common sub-themes. Once the components were identified in each analysis, respondents were given a score for each component with subsequent statistical tests focused on these component scores. In particular, MANCOVAs were conducted to compare the component scores across various respondent categories including, sex, MSGLC of school, and Indigenous population. Only those MANCOVAs revealing a significant result were pursued by undertaking univariate tests on each component separately, an analytical flow consistent with the logic set out by Tabachnick and Fidell (2001). Importantly, the MANCOVAs controlled for the effects of school size and socio-economic status of the school location, thus minimising any confounding effects of these variables on the results (Lyons et al., 2006).

Results and Discussion

Within this section the major findings from the survey are presented for each of the four main factors. Given that identical analyses were undertaken for the professional development, material resources, and student learning experiences items, full details are provided for the first analysis with reference made to this in later discussions.

Attraction and Retention of Qualified Mathematics Teachers

Teachers were asked initially to consider staff turnover rates by selecting the percentage of teachers leaving the school each year. Choices included: 0-10%, 11-20%, 21-30%, 31-50% and greater than 50%. Compared to their metropolitan colleagues, almost twice as many respondents from Provincial Area schools, and about six times as many from Remote Area schools reported a turnover rate of >20% p.a. These results were highly significant ($p < .001$).

In the next item, teachers rated the degree of difficulty experienced in filling secondary mathematics positions. Options included: Not difficult, Somewhat difficult, Moderately difficult and Very difficult. Significant differences ($p < .001$) emerged with secondary mathematics teachers in Provincial Areas twice as likely and those in Remote Areas about four times as likely as those in Metropolitan Areas to be working in a school in which it was “very difficult” to fill vacant teaching positions in mathematics (Table 3).

Table 3
Percentage of Mathematics Teachers in MSGLC Categories Selecting “Very Difficult”

		MSGLC categories				
		Metropolitan	*Provincial City*	*Provincial Area*	*Remote Area*	*Total*
Secondary Mathematics Teachers	Count	18	29	78	20	132
	% within Row item	12.4	20.0	53.8	13.8	100
	% within MSGLC	14.0	24.6	33.8	64.5	28.5

Subsequently, mathematics teachers were asked whether they were teaching subjects for which they were not qualified. Results were significant ($p < 0.001$) with twice as many teachers in Provincial Areas and four times as many in Remote Areas identifying the need to teach outside of their subject expertise (Table 4). However, when compared to the science and ICT results, mathematics teachers were least likely to be required to teach outside of their subject area. This finding probably relates to the national shortage of qualified secondary mathematics teachers.

Table 4
Percentage of Mathematics Teachers in MSGLC Categories Required to Teach Subjects for which they are not Qualified

		MSGLC categories				
		Metropolitan	*Provincial City*	*Provincial Area*	*Remote Area*	*Total*
Secondary Mathematics Teachers	Count	17	24	75	16	132
	% within Row item	12.9	18.2	56.8	12.1	100
	% within MSGLC	12.2	18.9	31.5	50.0	24.6

Professional Development Opportunities

When teachers rated items within this construct the areas of greatest need were professional development opportunities for teaching higher-order thinking, classroom management, organization and alternative teaching methods, and release from face-to-face teaching for in-school collaborative activities (Table 5).

A principal components analysis of these “need”-transformed items produced four substantive components: Mathematics Teaching Professional Development, General Professional Development, Development for Teaching to Targeted Groups, and Professional Relationships Development. Scores on these four components were analysed using a series of MANCOVAs in order to make specific group comparisons. Two MANCOVAs were conducted comparing mean component “need” scores by MSGLC categories and percentage of students with Indigenous backgrounds. Although the multivariate test for MSGLC category differences across the four professional development components was not significant, the multivariate test in relation to Indigenous students was significant ($p<0.001$).

A subsequent test revealed that the reasons for this result were due to a significant univariate difference for the Development for Teaching to Targeted Groups ($p < 0.001$) component and a suggestive difference for the Mathematics Teaching Professional Development component ($p<0.01$). Teachers from schools with more than 40% Indigenous students, and to a lesser extent from schools where the percentage was between 21% and 40%, indicated substantially greater levels of “need” for these two components than other teachers. These differences are identifiable in Figure 2 with a display of the profile plot of the original professional development “need” transformed items (ordered by component and labelled across the top of the graph) by percentage of students with Indigenous backgrounds.

Material Resources and Support Personnel

The average scores on the “need”-transformed items dealing with material resources and support personnel are provided in Table 6. Clearly, the areas of greatest overall “need” included having a suitably skilled assistant to help integrate ICT in the classroom, having appropriate numbers of computers for student use, having suitable learning support assistant(s), and having other computer hardware for teaching and learning mathematics.

Table 5
Summary of Average "Need" Scores, Standard Deviations and Valid N for Mathematics Teachers' Ratings for Professional Development*

Professional Development Items	*Mean*	*SD*	*Valid N*
Professional development opportunities: teaching of higher-order skills	10.70	3.91	492
Professional development opportunities: classroom management & organisation	10.47	4.04	496
Professional development opportunities: alternative teaching methods	10.34	3.98	494
Release from face-to-face teaching for collaborative activities	10.33	4.25	499
Effective communication between education authorities & teachers	9.92	3.72	492
Professional development opportunities: teach mathematics to gift/talented students	9.89	3.72	490
Professional development opportunities: integrating technology into math lessons	9.89	3.85	497
Professional development opportunities: teaching math to special needs students	9.77	3.96	493
Collaboration with mathematics teachers in other schools	9.65	3.61	501
Professional development opportunities: methods for using group teaching strategies	9.60	3.80	489
Opportunities for observing teaching techniques of colleagues	9.49	3.97	499
Workshops to develop your ICT skills	9.47	3.82	492
Involvement in region/state-wide syllabus development/research projects	9.29	3.90	493
Financial support to attend external in-services/conferences	9.04	4.00	498
Opportunities for mentoring new staff	8.90	3.68	501
Opportunities to attend external in-services/conferences related to T&L math	8.76	3.57	502
Professional development opportunities: use of graphics calculators	8.75	3.82	495
Professional development opportunities: outcomes/standards-based teaching	8.72	3.87	495
Opportunities to mark/mod external mathematics assessments	8.62	3.99	488
Professional development opportunities: teaching mathematics to Indigenous students	8.40	4.31	480
Professional development opportunities teaching mathematics to NESB students	8.29	3.99	459
Collaboration between mathematics teachers in your school	7.86	3.44	500

*Items arranged in descending order of mean "need" score between 1-20 (Adapted: Lyons, et al., 2006)

A principal components analysis of "need"-transformed material resources produced three components: ICT Resources and Support, Mathematics Teaching Resources and Support, and Teaching Resources for Targeted Groups. As with the earlier analysis, scores for the three components were analysed using a series of MANCOVAs. The multivariate test for MSGLC category differences across the three material resources components was not significant. However, the test comparing the three components across schools with different percentages of student with Indigenous backgrounds was significant (p<0.001).

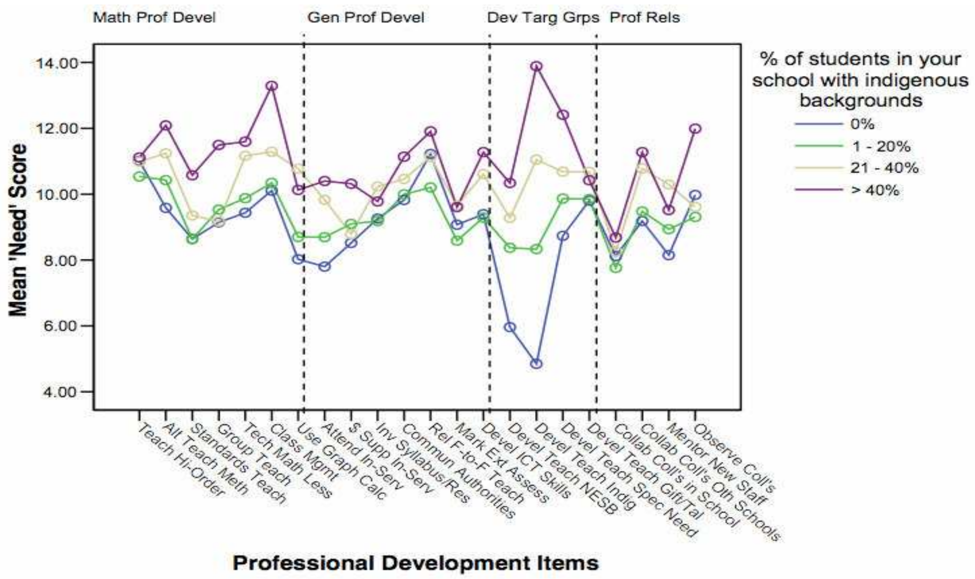

Figure 2. Profile plot of mean "need" scores of mathematics teachers for professional development components compared by percentage of students from Indigenous backgrounds (Table 5 lists full item names) (Source: Lyons et al., 2006).

A follow-up test identified that this difference was due to significant univariate differences on the Mathematics Teaching Resources and Support (p<0.001) and Teaching Resources for Targeted Groups components (p<0.001). Essentially, teachers from schools having more than 21% of students with Indigenous backgrounds indicated substantially greater levels of "need" for the two components when compared to teachers from remaining schools. Figure 3 illustrates that "needs" are greatest in the specific areas of resources for teaching mathematics to Indigenous students, having suitable Indigenous Education Assistants, students having access to scientific calculators, and having suitably skilled personnel to assist in integrating ICT in the classroom from schools having more than 40% of students with Indigenous backgrounds. In schools where the percentage of students with Indigenous backgrounds was between 21% and 40%, "needs" were greatest in the specific areas of resources for teaching to gifted and talented students and having concrete materials for mathematics teaching. Overall, it is clear that where the percentage of students in a school with Indigenous backgrounds exceeds 20%, "needs" are greater in most of these areas (Lyons et. al., 2006).

Student Learning Experiences

The areas of greatest overall "need" identified by mathematics teachers for these items (Table 7) included students having opportunities to visit mathematics-related educational sites, alternative/extension activities in mathematics teaching programs for gifted and talented and for special needs students. Interestingly, the results of this component was lower for mathematics teachers than science and ICT teachers suggesting that this was a moderate rather than high need.

A principal components analysis of these Student Learning Experience items highlighted three substantive components: Alternative and Extension Activities for

Targeted Groups, Teaching Context in the School, and Student Learning Opportunities. Subsequent analyses of these components using MANCOVAs identified that differences for the three Student Learning Experience components across MSGLC categories was not significant. Alternatively, the multivariate test between schools having different percentages of students with Indigenous backgrounds was significant (p<0.001).

Table 6

Summary of Average "Need" Scores, Standard Deviations and Valid N for Mathematics Teachers' Ratings of the Material Resources and Support Personnel items*

Mathematics Resource and Support Items	*Mean*	*SD*	*Valid N*
Suitably skilled personnel to assist in integrating ICT in your classroom	9.72	4.34	517
Appropriate number of computers for student use	9.44	3.69	520
Suitable learning support assistant(s)	9.24	3.61	523
Other computer hardware for teaching & learning mathematics	9.06	3.76	512
Suitable software for teaching & learning mathematics	8.91	3.69	520
Suitably skilled ICT support staff	8.87	3.75	518
Mathematical resources that address the needs of gifted/talented students	8.59	3.48	511
Suitable computer resources for teacher use	8.58	3.63	523
Mathematical resources that address the needs of special needs students	8.57	3.72	514
Suitable Indigenous Education assistant(s)	8.21	4.05	501
Effective maintenance & repair of teaching equipment	8.07	3.21	515
Sufficient mathematics equipment & materials	8.02	3.03	525
Fast, reliable internet connection	7.98	3.68	523
Mathematical resources that address the needs of Indigenous students	7.91	4.24	488
Concrete materials for mathematics teaching	7.85	3.11	524
Mathematical resources that address the needs of NESB students	7.80	4.05	462
Access range of internet mathematics resources	7.78	3.45	517
Student access to scientific calculators	7.55	3.30	520
Student access to graphics calculators for in class	6.84	3.41	519
Class sets of suitable texts	6.50	3.22	518
Suitable library resources for teaching & learning mathematics	6.46	2.97	515
Suitable AV equipment	6.39	3.24	520
Worksheets for classroom teaching	6.14	2.77	526

*Items arranged in descending order of mean "need" score between 1-20 (Adapted: Lyons, et al., 2006).

Further testing revealed significant univariate differences on the Teaching Context in the School (p<0.001) and Student Learning Opportunities (p<0.001) components as well as a suggestive difference on the Alternative and Extension Activities for Targeted Groups (p<0.01) component. The greatest level of "need" in the Teaching Context in the School component was demonstrated by teachers from schools having a percentage of Indigenous students between 21% and 40% while the lowest level of "need" was expressed by teachers in schools with no Indigenous students.

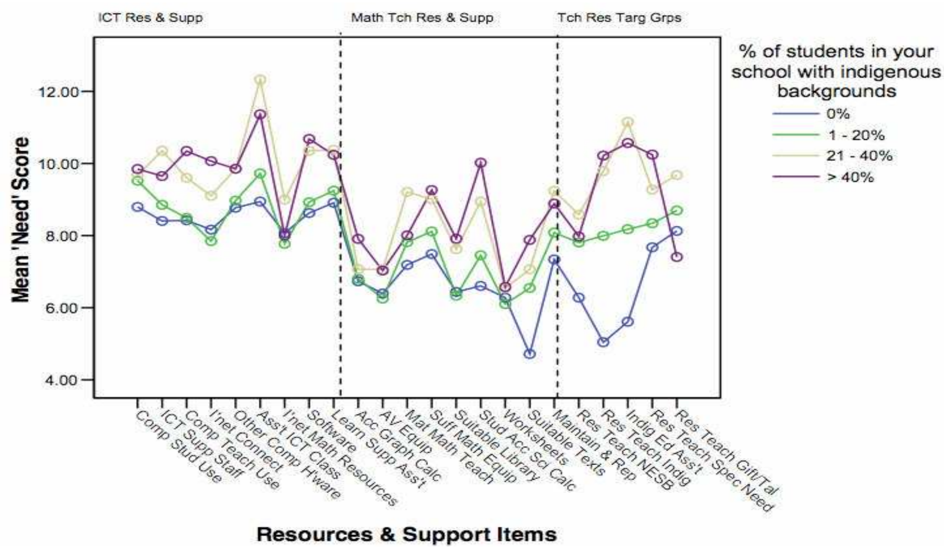

Figure 3. Profile plot of mean "need" scores of mathematics teachers for the Material Resources and Support Personnel components compared by percentage of students from Indigenous backgrounds (Table 6 lists full item names) (Source: Lyons et al., 2006).

Table 7
Summary of Average "need" scores, Standard Deviations and Valid N for Mathematics Teachers' Ratings of the Student Learning Experience*

Student Learning Need Items	*Mean*	*SD*	*Valid N*
Opportunities for students to visit mathematics related educational sites	9.36	3.70	505
Alternative/extension activities in mathematics teaching programs for gifted & talented students	9.22	3.58	500
Alternative/extension activities in mathematics teaching programs for special needs students	8.86	3.64	496
Alternative/extension activities in mathematics teaching programs for Indigenous students	8.47	4.16	474
Alternative/extension activities in mathematics teaching programs for NESB students	8.43	4.05	455
Teachers qualified to teach the mathematics courses offered in your school	8.15	3.06	505
Having the total indicative hours allocated to face-to-face teaching	8.12	3.48	492
Having the full range of senior mathematics courses available in your school	7.14	3.24	506
Student participation in external mathematics competitions and activities	5.92	2.49	510

*Items are arranged in descending order of mean "need" score between 1-20 (Adapted: Lyons, et al., 2006).

Teachers from schools with Indigenous populations of between 21-40% of students indicated a high "need" for alternative or extension activities with respect to all four targeted groups. Within the Teaching Context component, having a full range of mathematics courses on offer with total indicative hours allocated to face-to-face teaching reflected a markedly higher level of "need" from respondents from schools where 21-40% of students were from Indigenous backgrounds; having qualified teachers was at a high level of need for respondents from schools where the percentage of student with Indigenous backgrounds exceeded 20%. Within the Student Learning Opportunities component, teachers from schools where greater than 20% of students were from

Indigenous backgrounds indicated a substantially greater level of “need” in the area of opportunities for students to visit mathematics related educational sites.

Conclusion

The results from the survey suggest that teachers in Remote Area and to a lesser extent Provincial Area schools are likely to experience the effects of teacher shortages, a lack of opportunity to access professional development, and difficulties in providing resources for their students to a greater extent than teachers in Metropolitan and Provincial schools. However, it was interesting that significant differences did not emerge consistently for these components across MSGLC categories for mathematics teachers whereas this was the case for science and ICT teachers. Alternatively, significant differences emerged across the MSGLC categories when the percentage of Indigenous Students higher than 20% was considered as a variable. Addressing the needs of our Indigenous Students highlights a critical area for which our mathematics teachers seek major support.

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