





Implications of Message Length and Delay in Undergraduate Online Discussions

Implicaciones de la extensión y demora de los mensajes en discusiones en línea con estudiantes de grado



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ABSTRACT

This study aimed at verifying the association of message length and delay in university online discussions with academic achievement and students' influence on their classmates. Forums in Moodle were designed, and asynchronous online discussions with first-year undergraduate students of Educational Sciences were conducted. We gained word count from the learning management system, the weekly delay in posting a message to the forum was regarded, and we assumed the students' grades to know their academic success. To obtain an indicator of influence, we conducted a social network analysis from the interactions that emerged from the online discussions. Then, we calculated the eigenvector centrality of each student once the debate had been completed. Results showed a low monotonic association between grades and the message words or the delay in posting. There was a slight trend to achieve more eigenvector centrality since students took more time to send a message and when messages were more synthetic. However, we did not obtain values in the coefficients that would allow us to infer a relevant association. The level of correlation detected for the grades was significant and, above all, regarding eigenvector centrality. We discussed the limitations of this study, the need for more research, and the implications for educational practice.

Keywords: discussion; social learning; didactic use of computer; educational technology; network analysis; university.

RESUMEN

El objetivo de este estudio fue comprobar la relación de la extensión y la demora de los mensajes en discusiones en línea con la influencia entre estudiantes y el rendimiento académico en la universidad. Se diseñaron foros en Moodle y se llevaron a cabo discusiones asíncronas en línea con estudiantes de primer año de Ciencias de la Educación. Obtuvimos el recuento de palabras desde el sistema de gestión del aprendizaje, consideramos el retraso semanal para publicar mensajes en el foro y tomamos las calificaciones de los estudiantes para conocer su éxito académico. Para obtener un indicador de influencia, llevamos a cabo un análisis de redes sociales a partir de las interacciones en los debates. Después calculamos la centralidad de vector propio para cada estudiante, una vez finalizado el debate. Los resultados mostraron una correlación monotónica baja entre las notas y la extensión de los mensajes o el retraso en publicarlos. Hubo una ligera tendencia a conseguir más centralidad de vector propio a medida que se tardaba más en enviar un mensaje y cuando los mensajes eran más sintéticos. Sin embargo, no hubo valores en los coeficientes que permitieran inferir una asociación sustantiva. El nivel de correlación detectado para las calificaciones fue significativo, sobre todo para la centralidad del vector propio. Discutimos las limitaciones del estudio, la necesidad de más investigación y las implicaciones para la práctica educativa.

Palabras clave: discusión; aprendizaje social; uso didáctico del ordenador; tecnología de la educación; análisis de redes; universidad.

INTRODUCTION

Since the turn of the century, Higher Education institutions around the world have increasingly invested in educational technology and learning management systems (Bond et al., 2020; Müller & Wulf, 2020) and even more so in the Covid-19 pandemic (Abu Talib et al., 2021; Z. Chen et al., 2021). Asynchronous Online Discussion (AOD) is a didactic method used a little while back via Information and Communication Technologies, which has had an appreciable impact and usefulness (Andresen, 2009; Fehrman & Watson, 2020; Gao et al., 2013; Thomas, 2013).

Online discussion favors the development of complex learning at university (Jeong & Chiu, 2020; Tirado Morueta et al., 2016), increases student-student interaction (Almatrafi & Johri, 2019), helps establish networked learning communities (Saqr et al., 2020), and works for the social construction of knowledge (Al-Dheleai et al., 2020). The advantage of asynchronous debates is to give students time to learn about a discussion topic, build their position about it, and then offer an argued response to their classmates.

Moreover, several studies published in the last years analyzed the social networks that emerged from interaction during the AODs (e.g., Garcia-Garcia et al., 2021; Lee et al., 2021; Zou et al., 2021). The results from social network analysis (SNA) showed that AOD fosters learning how to influence other people through dialogue and deliberation, beyond disciplinary learning in a subject.

Despite the benefits of AOD, controversy has lately arisen in the academic community about the quantity versus quality of student activity on virtual platforms. One of the issues is that the time they spent online may have misled the results of the debates in previous studies (e.g., Campbell et al., 2008; Pulford, 2011). The problem with measuring online time is that it lacks relevant practical information to know the students' engagement or participation online. Another problem is that, while some research focused on message length to assess learning outcomes (e.g., Brooks & Bippus, 2012; Vázquez-Cano et al., 2015), we doubt whether the message length is associated with academic performance or influence on classmates.

This background led us to design and conduct a study to provide empirical evidence to confirm or rule out the importance of message length and delay in academic performance and student influence in undergraduate AODs.

LITERATURE REVIEW

The time spent online may be misleading the results of AOD

The latest reviews of AOD research (Almatrafi & Johri, 2019) revealed that the assessment of discussions often consists of counting the time spent online (Campbell et al., 2008; Pulford, 2011) or the number of posts (Saadatdoost et al., 2015). The problem is that these factors serve more to record the level of online activity than

to assess learning, especially connection time since we do not know the offline work time involved in writing a post. It is more, we cannot even be sure that students stay working the whole time logged into a learning management system like Moodle or Blackboard because we ignore what they might be doing behind the screen.

Although the time online and the number of posts require to manage digital skills, these skills are a condition to participating in AOD (Junus et al., 2019; Onyema et al., 2019) and do not constitute a learning outcome from the discussion. In any case, it would be reasonable to think that those students who post less frequently have invested more time in crafting the content of their messages, but we have no evidence about that. So far, some studies have analyzed the effect of the delay in posting messages to the forum, but it was the teacher's delay, not the students' (Mazzolini & Maddison, 2007). That led us to wonder if there is any relationship between the time it takes students to post and their academic performance or other learning outcomes.

We ignore whether message length is associated to academic performance

Research has long taken students' word count in forums to measure their interaction, engagement, and even performance (e.g., Brooks & Bippus, 2012; Vázquez-Cano et al., 2015). Many authors still consider word count as a relevant sample data and report it (e.g., Hülsmann & Shabalala, 2016; Sanganyado & Nkomo, 2018; Stephens et al., 2019). In fact, a recent study measured the number of words and assumed it was equivalent to students' social involvement in AODs (Law et al., 2020).

Concerning teamwork, we recognize that sentence length and message word count usually contribute to better team member performance (Ahuja et al., 2020), but that does not necessarily entail gains in the students' qualifications. It will depend on the assessment criteria and the aims of each subject at the university. Nor does performance on teamwork need to mean that students develop other individual aspects of their learning process at college, such as managing the information they share in discussion forums or the metacognitive skills to schedule their work.

Regardless of grades, another study found a significant difference in the variance of message length when students were informing their classmates and when they were referring to the task situation (Chávez et al., 2016). After all, it seems that certain words could predict academic achievement, especially when they have a relevant and qualitative connection to the discussion topic (Lin et al., 2020; Yoo & Kim, 2012, 2014).

Perhaps this is why some evidence showed that the number of words students write in an AOD predicts academic performance (Abe, 2020). Nonetheless, it would be necessary to conduct more correlation studies to reinforce the empirical evidence and verify that the results were not due to perturbing variables, such as the

importance of the words for the topic of discussion and the information shared in the posts.

The contribution of SNA to assess the student influence in AODs

Beyond grades, AOD involves a formative process based on constructivist pedagogy and the socio-cognitive approach. It develops higher mental functions from the student-student interaction (Bandura, 1986; Vygotsky, 1978), facilitating the accommodation of new ideas into prior cognitive structures (Ausubel et al., 1968; Greco & Piaget, 1959).

In this line, students learn when they give validity to the arguments of their peers (Habermass, 1984) and, therefore, the influence they exert on each other is a relevant factor to learn. However, students' grades and engagement (i.e., time spent online, number of posts, website visits, and similar factors) do not always reflect their influence on classmates. That may depend on the teacher's assessment criteria and the quality of the messages. Perhaps the length and delay of posts bear some association with student influence, independent of grades.

SNA provides metrics on the students' interaction patterns, which may be more or less active or isolated in the network (García-Álvarez et al., 2018). In particular, it allows assessing interaction from centrality metrics (da Silva et al., 2019; Lee et al., 2021; Zou et al., 2021), which indicate how much and in what sense each student's messages are important for their classmates. We have already taken centrality as an indicator of influence and proposed to use this information for formative objectives during a course (García-García et al., 2021).

Centrality indicates a location for each student relative to the network, and some centrality metrics report on the ability to influence the arguments of others. That does not mean that occupying a central position in the network ensures real student influence. That will depend on the content of the messages. A long post with hardly any information will influence without content. In other words, there will be a formal influence, but it will not change others' minds. Still, a central position makes it easier for students to influence the reasoning of others. Thus, in this study, we included centrality as a learning outcome from AOD, in addition to grades.

Research questions

This study aimed to test the hypothetical correlation of message length and delay in AODs with academic achievement and influence on classmates. We answered the following research questions (RQ).

- RQ1. Was the message word count associated with the students' grades?
- RQ2. Was the message word count associated with the students' centrality?
- RQ3. Was the delay in sending a message associated with the students' grades?
- RQ4. Was the delay in sending a message associated with the students' centrality?

METHOD

We designed a two-group posttest-only study because the focus was the association of message words and delay in sending with students' marks and their influence on classmates. The study focused on proving or ruling out the existence of correlations to optimize efforts for predictive designs in AOD research.

Sample and participants

The sample was 1283 messages by 93 students of Educational Sciences who participated in AODs during the first year of their undergraduate studies. The activity endured ten weeks for 48 of them and fourteen weeks for the others. The teachers moderated the debate and participated in the AODs only to initiate the discussion threads. We excluded the teachers' messages from the analysis.

All students were between 18 and 31 years old (Mean = 19.84, Standard deviation = 2.16). Seventy-seven of the students were female (82.80%), and the rest were male. We admitted the gender imbalance because it corresponded with the population data of our university. According to the institution's yearbook, more than 85% of the students enrolled in Educational Sciences were female during the last three academic years.

Table 1 shows the features of the sample. We reported median values and interquartile ranges instead of mean and standard deviation because data were not normally distributed, and we considered robust central tendency and dispersion measure more representative.

Table 1
Descriptive statistics

	Word count	Message delay	Grades	EV Centrality ^a
n	1283	1283	93	93
Median	103.0	110.0	7.000	0.238
IQR ^b	76.50	97.22	2.000	0.484
Minimum	8.000	0.000	4.000	0.000
Maximum	548.0	168.0	10.000	0.963
Shapiro-Wilk	0.8921	0.8781	0.924	0.900
<i>p-value</i>	4.831e-29	1.507e-30	4.272e-5	2.953e-6

^a Eigenvector centrality

^b Interquartile range

Learning environment

The teachers set up discussion forums in Moodle with a semi-structured format (Dommett, 2019; Hammond, 2019). The activity in the forums consisted of students following a discussion thread, posting comments on a lesson of the course. The contributions had to refer to other messages that classmates previously posted. The teachers used the Urkund system to detect plagiarism in each post and progressively penalized the students' marks from plagiarism higher than 15%.

It is probable that providing alerts, reminders, or somehow facilitating the activity in the forum help students read and respond to their peers more frequently (Wang & Yang, 2012). However, these automatic notifications could reduce their cognitive load and negatively affect their attention span (Sachdeva & Gilbert, 2020). Thus, we suggested the self-management of the activity and using the Moodle search engine to find messages of interest instead of providing any additional facilities. In doing so, we aimed to achieve the participation required for the proper development of the AOD (Hew & Cheung, 2008).

We also disabled the option to modify messages in the forum once posted, as we needed to assess the students' progress since the original posting date. The students had no access to their grades in the AOD nor to the overall qualifications of the course. Thereby this information could not influence their performance during the debate.

Procedure and data management

At the end of the semester, we downloaded the data of the posts directly from the forum in Moodle. With this procedure, we obtained the word count in each message and the grades, but not a score that would provide information on how long it took students to post their comments. Then, we calculated the message delay based on the minutes elapsed over the weeks in the range of 0-168 hours (one week).

We considered each week an isolated block of time, starting every Monday a new period to comment on the discussion topic and including weekends because some students found it easier to participate in the discussion on non-working days. We recommended they post at least once a week to encourage discussion.

The students had to include references to the previous remarks of their peers in the text they were posting every time. That allowed us to obtain an adjacency matrix with all interactions to analyze the network that emerged from the debate. The SNA provided centrality scores for each student that helped to detect candidates with a high capacity to influence the arguments of their classmates.

Data analysis

We first computed the students' centrality scores as an indicator of influence on their peers. Then, we assigned their marks and their centralities in the discussion networks to each post and conducted the correlation analysis. The following sections contain details on the SNA and the hypothesis testing.

Social Network Analysis

AODs generated social networks that made it possible to assess the students' connectivity. The simplest way to obtain centrality is to sum the number of links a node $v \in V$ had, with v being the node and V being the set of nodes in the network. That is known as degree centrality. These links are the degrees that each node had, representing the nodes to students. In a directed network such as the one we analyzed, there were in-degrees when the node was the final vertex of the link or edge and out-degrees when the node was the initial vertex.

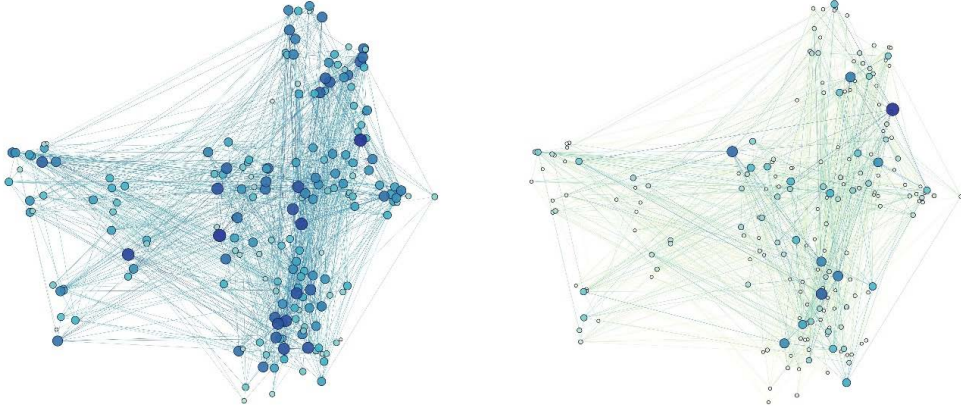
Still, we obtained the degree of connectivity of each person and used it to calculate their eigenvector (EV) centrality instead of degree centrality. We dispensed with degree centrality because it reflected only the number of connections when students addressed others –outdegree– or other classmates interpellated them –indegree– (Diestel, 2017). Instead, we took EV centrality as a reference because it corresponds to the principal eigenvector of the network adjacency matrix. Therefore, it provided more information about the influence that some students had on the insights of others during the discussion.

Figure 1 helps to understand the difference between the two concepts. It contains a random network with 200 nodes representing students who participate in an AOD with a .05 probability of connection. In the version on the left, the nodes with a higher degree appear painted in darker blue. The version on the right is the same but based on EV centrality instead of degree centrality.

Students with higher EV centrality interact with many peers who, in turn, are well connected to others within the online learning community (Negre et al., 2018; Newman, 2010). We used EV centrality to detect students who may spread their information successfully during the debate, sharing meaningful learning content with their peers.

We computed EV centrality from the product of Ax , with A being the adjacency matrix and x being the vector that resulted from the degree centralities of those students directly connected to a person (Bonacich, 1972; Sun & Tang, 2011). Thus, EV centrality correlates strongly with degree centrality, although it is somewhat more associated with indegree than with outdegree (He & Meghanathan, 2016; Valente et al., 2008), and considers the level of connection of the people to add or subtract weight to the value of the student-to-student links.

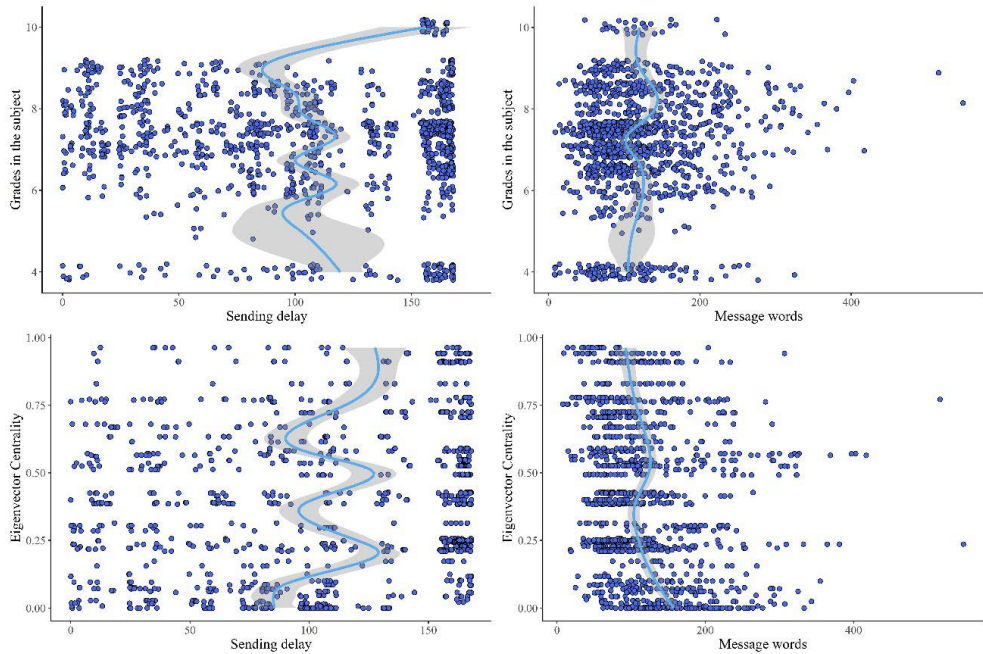
Figure 1
Degree and EV centralities



Correlation analysis

We obtained nonparametric correlation coefficients because of the non-compliance with the normality assumption, and in a preliminary exploration, we ruled out the possibility of a linear relationship. Figure 2 provides scatter plots from that exploration with smooth lines from estimates of the conditional mean function and 95% confidence intervals in grey for each pair of variables. Given the findings, we looked for evidence about monotonic relationships to assume or discard message words and the delay in sending as potential predictor variables for qualifications and influence on others during an AOD.

Figure 2
Preliminary exploration of the data



Considering that correlation coefficients would be low, we computed Vovk-Sellke Maximum p -Ratio (Sellke et al., 2001; Vovk, 1993) to report the likelihood of a particular p -value. The p -value gives the probability of obtaining results in a test that are at least as extreme as the results observed in the data, assuming the null hypothesis of no correlation is correct. When the p -value is small, an extreme outcome would be unlikely under the null hypothesis, and we then rule out the absence of correlation.

In other words, the p -value provides information about the probability of the data given a distribution. However, the Maximum p -Ratio provided information about how many times more likely a p -value is to occur under the alternative against the null hypothesis. That allowed us to discard message length and its delay in further studies on AOD with undergraduate students. In this case, the Maximum p -Ratio was based on the p -value, and the maximum possible odds in favor of the alternative hypothesis over null equals $1/(-e p \log(p))$ for $p \leq .37$.

RESULTS

Nonparametric tests revealed weak correlation coefficients. We detected a low association between grades and either the message words or the delay in posting. There appeared to be a slight tendency to achieve more EV centrality as students took more time to post their comments in the forum. We also found a weak trend to achieve more EV centrality when messages were more synthetic. However, we did not obtain values in the coefficients that would allow us to infer more than a low correlation in any of the four hypotheses.

The level of correlation detected for the grades was significant ($p < .05$), and even more so for the associations with EV centrality ($p < .001$). After computing the Maximum p -Ratio from the test for grades and message words, we found it was five times more likely for the p -value to occur under the alternative hypothesis against the null.

In the test for the correlation between the marks and the delay in sending a post, the p -value was seven times more likely, and it was much prominent in the tests for EV centrality. That means that there was a low correlation in both tests, and we can affirm it in a significant and likely assertion. Table 2 contains the correlation coefficients, two-tailed significance, and Maximum p -Ratio.

DISCUSSION

For decades, research on AOD sometimes assessed the engagement and outcomes of the students measuring the time they spent online (Campbell et al., 2008; Pulford, 2011) and the length of their messages (Brooks & Bippus, 2012; Law et al., 2020; Vázquez-Cano et al., 2015). Literature review showed that this practice would be controversial because it does not correctly reflect student learning outcomes (Almatrafi & Johri, 2019).

Our study provided empirical evidence pointing to a low association between message length and delay with academic achievement and the influence on classmates. Although the association was statistically significant, it was not of meaningful practical relevance. In the following sections, we suggest evidence-based guidelines for educational practice and discuss the limitations and implications of the study for future research.

Table 2
Correlation analysis

RQ		1	2	3	4
Contrast		Words - Grades	Words - Centrality	Delay - Grades	Delay - Centrality
Spearman	rho	.067*	-.229***	-.070*	.148***

RQ		1	2	3	4
Contrast		Words - Grades	Words - Centrality	Delay - Grades	Delay - Centrality
	95% CI ^b	.012, .121	-.280, -.176	-.125, -.016	.094, .201
	<i>p-value</i>	.017	1.094e-16	.012	1.095e-7
	VS-MPR ^a	5.272	9.150e+13	7.061	209577.175
Kendall	tau B	.046*	-.155***	-.052**	.098***
	95% CI ^b	.009, .083	-.191, -.119	-.089, -.014	.066, .130
	<i>p-value</i>	.021	2.273e-16	.009	1.799e-7
	VS-MPR ^a	4.61	4.494e+13	8.538	131675.226

* $p < .05$, ** $p < .01$, *** $p < .001$

^a Vovk-Sellke Maximum p -Ratio

^b 95% Confidence Interval

Implications for educational practice

The length of time an assignment lasts can affect student engagement in virtual learning environments. A recent study examined online teaching practices during the Covid-19 pandemic and found that the time elapsed between the beginning of the task and the last submission of the students was associated with academic performance (Schmitz & Hanke, 2021).

Indeed, student engagement influences academic achievement and motivation to learn and reduces apathy and dropout rates (Assunção et al., 2020; Maguire et al., 2017). However, our study showed the relationship between time and performance was scarce when we analyzed the delay in posting messages in an undergraduate online discussion.

Although we remain unaware of the students' work during the time they spend online, the findings showed that those who take longer to publish a post do not necessarily get better grades, nor do they have much more influence on others' arguments. Consequently, it makes no sense to encourage students to submit their posts earlier or later, believing that it will help them. They should meet deadlines when applicable, but the time they take to send a message will not improve their academic performance or the acceptance from the rest of the class.

Message length is also not an indicator of quality. We found a weak trend to achieve more EV centrality when messages were more synthetic, but it was slight ($r_s = -.229$, $p < .001$), and it would not be advisable to encourage students to write longer or shorter comments. Instead, it would be reasonable to teach them to write messages that make sense for the discussion topic and, if possible, that do not leave the discussion thread.

Previous studies reached similar conclusions in online activities (Jivet et al., 2020), particularly in online discussions using network analysis to assess outcomes (Amastini et al., 2020; Lahuerta-Otero et al., 2019). That reinforces the research pointing that only the number of words related to the discussion topic goes so far as to affect student performance (Lin et al., 2020; Yoo & Kim, 2012, 2014).

Limitations and emerging research

Measuring academic success from grades was somewhat limited. Students develop knowledge and skills aside from course objectives or assessment criteria and nevertheless are beneficial for professional development. Qualifications may reflect the adaptive ability of the students to the teachers' demands rather than the academic performance itself.

EV centrality is also not a thorough indicator of influence. It indicates a position in the network with vast possibilities to influence peers, but it may not include meaningful content to learn about the discussion topic. After all, SNA is increasingly used to analyze the spread of disease (Block et al., 2020; Silk et al., 2017) or organized crime networks (Bouchard, 2020; Burcher & Whelan, 2018), and situations of disrespect and aggression can occur in AODs (Yapici & Akbayin, 2012).

Students with a higher level of EV centrality could propagate this kind of content, thus exerting a negative influence. Teachers' modeling the forms of interaction (Choi & Johnson, 2005; Smet et al., 2010) and adopting strategies for moderating the debate (N.-S. Chen et al., 2011) should be enough to avoid these situations. However, mitigating negative behavior does not mean that the most influential students always share positive content or at least content that helps their classmates to learn about the discussion topic. Even so, EV centrality and grades provided a more complete and rigorous measure than other alternatives, such as self-report tests.

In this line, we consider it relevant to analyze the content of the messages and not only the structure of the networks, as pointed out by previous studies (García-García et al., 2021; Jan & Vlachopoulos, 2019). The content of the posts would be more effective than message length and delay in helping students to learn and exert a positive influence on others. Therefore, in future research on the impact of AOD on academic performance or student-student communication, word count or the delay in sending a post will be of little interest.

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