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Quantitative and Qualitative Approaches of User Engagement on Facebook* Fan Page

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Abstract. User Engagement is a metric that represents a part of the user experience characterized by attributes of reactions, visibility and user interactivity with others. Quantitative and qualitative analysis were used to establish a new method for calculating User Engagement in Facebook* fan pages focused in dissemination of scientific content, news, and events. We focused on social media processes based on Spearman correlation coefficients and categorization of publications by format type and source of content. Variations in Engagement for individual posts were explained by a multiple linear regression model defined using the number of clicks and the reach of posts with an accuracy of up to 91% (R^2). The User Engagement increases preferably when it is presented in photo format of an original content creation.

Keywords: regression model; Facebook*; Spearman correlation coefficients; user engagement.

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Количественные и качественные подходы к изучению уровня вовлеченности пользователей Facebook*

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Аннотация. Вовлеченность пользователей – это показатель, демонстрирующий ту часть пользовательского опыта, которая характеризуется атрибутами реакции, видимости и взаимодействия пользователя с партнерами. Для создания нового метода расчета вовлеченности пользователей на фан-страницах Facebook*, ориентированных на распространение научного контента, новостей и событий использовался количественный и качественный анализ. Авторы были сосредоточены на процессах в социальных сетях, основанных на коэффициентах корреляции Спирмена и категоризации публикаций по типу формата и по источнику контента. Различия в привлекательности для отдельных постов были объяснены с помощью модели множественной линейной регрессии и подсчета количества кликов и уровня доступности постов с точностью до 91% (R2). Размещение в сети оригинального контента и фотографий существенно сказывается на росте пользовательской вовлеченности.

Ключевые слова: регрессионная модель; мессенджер Facebook*; коэффициент ранговой корреляции Спирмена; вовлеченность пользователя.

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1. Introduction

Social networks have been used as a tool that stimulates interaction, shaping new forms in which people communicate, make decisions, socialize, collaborate, and learn [1-2]. In social networks it is features provide unique and interesting conditions for investigating the interaction of multiple individuals and the incorporation of organizations in user's self-expression [3-4]. There are research papers on social networks, which have used Cloud Computing, broadband networks, Big Data Analysis [5], text analysis [6] and smart devices like internet of people does [7].

Interactivity of social networks, particularly Facebook*, can be used to study the impacts of users' increase of activity towards a specific brand [3, 8], products [9], services [10] and benefiting from

new opportunities [11]. On this way, Facebook* measures interactions by means of Engagement and other metrics [9].

Engagement is obtained from the behavior shown by users through their activity on social networks [2-3, 12]. This is a quantitative metric of the bidirectional interaction between organizations and users of social networks [9]. Through the data collected from Facebook* and the metrics used, a post (publication) can be evaluated [9, 13], but the User Engagement and Engagement Rate formulas, provided by Facebook*, calculate Engagement, but do not reveal the differences between participation levels [14].

The research objectives are to analyze how metrics on Table 1 are correlated with the calculation of User Engagement. Then, using those metrics as independent variables to create a regression model to interpret User Engagement in Facebook* fan pages with an interest on dissemination of scientific information and activities.

Table 1. Facebook Quantitative Metrics*

Metrics	**Description**
Reach	The number of people who viewed the post at least once. Does not include people who saw your story when another user shared it.
Impressions	The number of people who viewed the content in News Feed, no need to interact with the post.
Clicks	The number of clicks on posts that led to destinations or experiences on or off Facebook*.
Reactions	The total number of reactions on the post. This includes "like", "love", "haha", "wow", "sad", and "angry".
Comments	The total number of user comments on the post.
Shared	The total number of times users shared the post. This includes in your profile or as a private message.

In this study, the emphasis is on the fact of incorporating social networking processes for the dissemination of scientific content, as a mutually beneficial collaboration between universities and research centers with society, that makes research information and knowledge useful outside the academic community, helping them to establish specific interest groups. To this end, the following hypotheses were established:

- H1 User Engagement changes as a function of content type
- H2 User Engagement is larger for original content.

*2. User engagement calculation on Facebook**

When logging into to Facebook*, is possible to manage fan pages or groups that enable other types of communication and strategies aimed mainly at organizations, institutions, and social or commercial ventures [2, 15].

Some investigations about Facebook*, on fan page or groups, found posting types and topics have a significant effect on Engagement. In [16] authors suggest Poisson regression models to be deployed to analyze the collected data and assess the effect of brand posts characteristics related to online Engagement. The data Facebook* regression analysis made by [13] indicated that Engagement is positively affected by posting visual content (photos), negatively affected by evening posting, while Post frequency displays no statistically significant effect on Engagement.

The authors in [17] and [18] performed linear and multiple regression models to understand the relationship between cultural values and users' engagement with Facebook* advertising and found that attitude to Facebook* advertising, subjective norms and perceived herd behavior positively

determines the Engagement. In the work of [19], qualitative research was conducted on Facebook* users and their activity on the social network. The authors in [20] presented a study with mixed qualitative and quantitative approach, where they integrate the opinion of experts and subsequently proceed to analyze the data statistically, implementing the calculation and analysis of engagement based on metrics from Facebook*. The User Engagement analysis [8, 13, 17, 21-22] and its prediction continue to be an area of opportunity to identify the acceptance of content on Social networks [23-24].

Having an index from the variables implemented by different formulas and models supports the identification of an integrated measure of Engagement, underscoring the importance of having the parameters normalized [12]. There exist diverse formulas and models for calculating User Engagement based on data obtained from Facebook* fan pages or groups (Table 2).

In Facebook*, User Engagement is calculated as the sum of all interactions in the post (equation 1).

$$\text{User Engagement} = N_R + N_c + N_S \quad (1)$$

where:

- N_R, Number of reactions on the publication.
- N_C, Number of comments on the publication.
- N_S, Number of times the publication has been shared.

Considering the proposals of the related work, a User Engagement regression model is proposed to measure the effect of each metrics associated to a Facebook* fan page focused on topics of scientific dissemination.

*Table 2. Formulas to calculate User Engagement on Facebook**

N_L = number of likes N_R = Number of reactions

N_C = Number of comments N_S = Number of times the publication has been shared N_F = number followers

Authors	Proposed Formula
Bonsón & Ratkai, 2013 [25]	$\frac{N_L + N_S + N_C}{\frac{N_{Message\ \ fanpage/group}}{N_F}}$
Niciporuc, 2014 [26]	$\frac{N_L + N_S + N_C}{N_F}$
Oviedo-García et al.,2014 [9]	$\frac{\frac{N_L + N_S + N_C}{N_F}}{\frac{X_{j\ (Interactivity)}}{\mu_{Scope\ fanpage}}}$
Herrera-Torres (2017) [27]	$\frac{N_R + N_S + N_C}{N_F}$
Ge & Grezel, 2017 [28] Eriksson et al., 2019 [12]	$N_R + 5N_S + 10N_C$
Vadivu & Neelamalar (2015) Peruta & Shields, 2017 [29]	$\frac{N_R + N_S + N_C}{N_{likes\ fanpage}} \text{x } 100$
Phuntusil & Limpiyakorn, 2017 [30]	$\frac{N_R + 5N_c + 10N_s}{N_{Likes\ fanpage^{0.8}}} \text{x } 10^4$
Ballesteros-Herencia, 2018 [31]	$\frac{N_R + N_c + N_s}{Scope\ post} \text{x } 100$
Jayasingh Sudarsan, 2019 [17]	$\frac{N_R + 5N_c + 10N_s}{N_{Likes\ fanpage^{0.8}}} \text{ x } 100$

Martínez-Sala & Segarra-Saavedra, 2020 [22]	$\frac{N_R + N_c + N_s}{N_{Post} \times N_{Fans}} \text{x } 100$

In this way, the following questions addressed this research are:

(RQ1) What is the best regression model to explain User Engagement on Facebook*?

(RQ2) Which content type generates a higher percentage of User Engagement?

(RQ3) What is the correlation between the different variables related to Facebook*?

3. Research methodology

The methodology used is an adaptation of the phases proposed by [24] and extended with the tools and roles of [2].

3.1. Data Preparation

During data preparation phase a Facebook* fan page (FP) for thematic elements around disseminating scientific content was selected as a study case (https://www.Facebook*.com/mujeresinvestigacion). This fan page is part of a scientific dissemination program of Instituto de Ingeniería of the Universidad Autónoma de Baja California, Mexico. Data were obtained in the form of a CVS file from Facebook* Insights, containing interaction details for 166 posts from the year 2022. Five different categories of posts were identified in Table 3 (link, event, photo, podcast, video).

Additionally in Table 4, a categorization was created, corresponding to the origin of the material presented in the posts:

1) external scientific fan page,
2) external universities FP,
3) our university FP,
4) study case, and
5) posts related to the activities of an external dissemination event in which some members of the extension program participated.

To carry out the data preprocessing process, the Anaconda and RStudio tools were used.

3.2. Engagement Interpretation

To examine the relationships between Facebook* metrics with the User Engagement calculation, an analysis was carried out using the importance of the extracted metrics and the results of Spearman correlation coefficients [18]. The preprocessed Facebook* data allowed us to obtain proposals for a regression model with a better fit for Engagement.

4. Data analysis and findings

4.1 Analysis of the variables

To answer to H1 and H2, Tables 3 and 4 present a detailed characterization of posts. The categorical variables allowed an analysis of the means and clearly present the frequencies of each identified element. For User Engagement, equation 1 was used, where the highest value was obtained from photo-type posts (120, $\mu = 25$), followed by video-type posts (13, $\mu = 17$) in which at least three of these posts were above average (H1). A first approach to the behavior of the data can be seen in Fig. 1 with User Engagement by type of post.

The highest concentration of elements on the fan page corresponds to photos (72% of the content), and coincides with the element that has the highest User Engagement. Regarding the original content of the fan page (Table 4), they have been separated into fan page study case and Dissemination event. For these cases, User Engagement was higher for posts related to the dissemination event (μ

= 166) than for regular posts of the fan page (μ = 16.5). Responding to H2, it is observed in the data that for both categories of original content, the engagement was higher than in the others. But in content generated for a specific objective (Category 5 in Table 4), the Engagement mean was even higher.

Table 3. Characterization of the posts by type of content

Categories	Frequency	Percentage	μ Engagement Formula
Link	16	9.63	12
Event	14	8.43	16
Photo	120	72.28	25
Podcast	3	1.80	18
Video	13	7.83	17
Total	166	100	

Table 4. Characterization of the post by source

Categories	Percentage	μ Engagement Formula
1. External FP	15	13
2. External Universities FP	9	10.5
3. Our University FP	27	12.5
4 Study case*	16	16.5
5. Dissemination event*	33	166

* Original Content, FP = Fan page

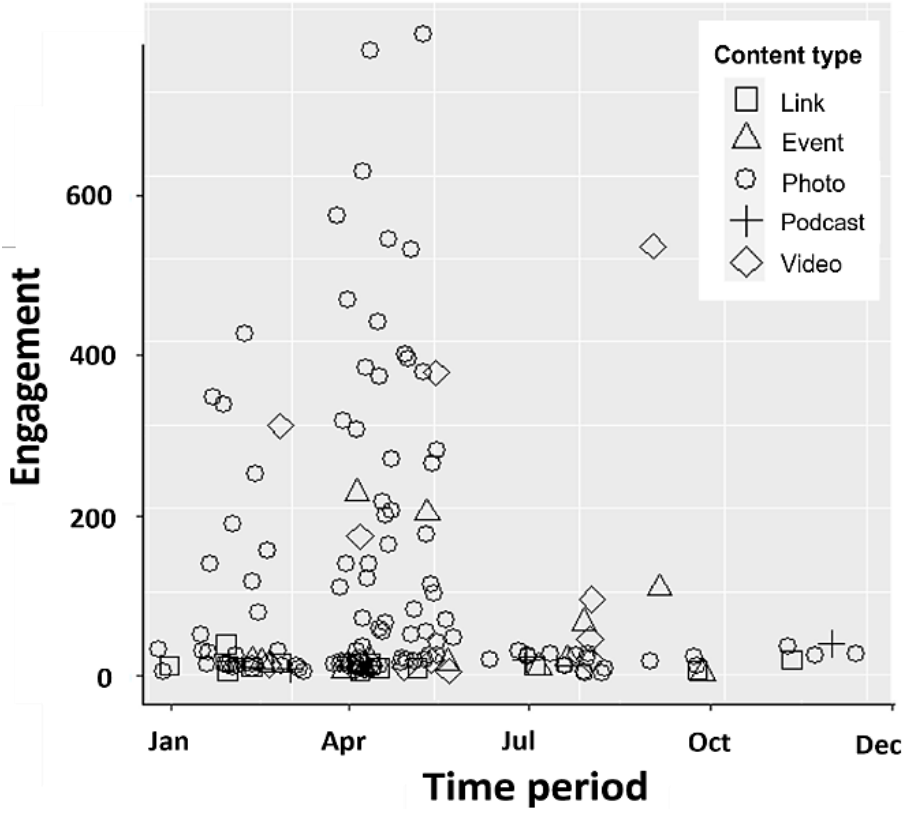

Fig. 1. Graph with the content type shared by the fan page over a span of one year

Fig. 2 allowed us to observe the Coefficient correlations between the different metrics extracted from the data set. This helped to verify the relationship between Reach and Impressions as causal variables, so it was decided to rule out the use of the impressions variable when generating the regression model.

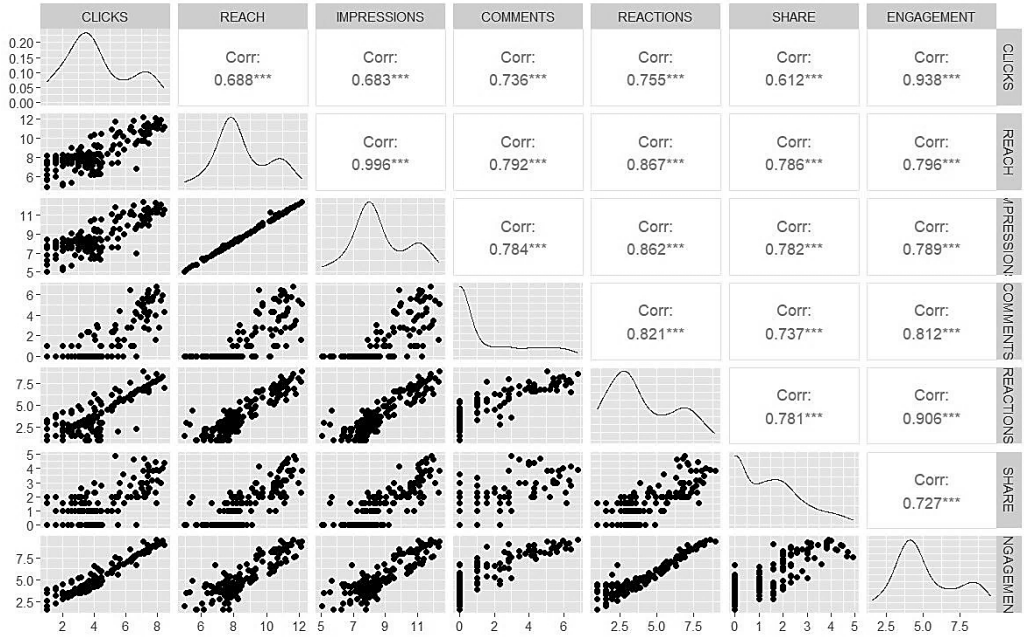

Fig. 2. Spearman correlation coefficients calculation

4.2 Analysis of regression models

Based on the data set obtained for the behavior of the FP, and the categorical variables, several multiple regression models were explored (Table 5), with the purpose of obtaining an adjusted model that integrates most of the variables available for the calculation of User Engagement, omitting the reactions, comments and number of times it is shared. This in order to avoid multicollinearity [8].

First, we validated the variables using the values of the Spearman correlation coefficients (Fig. 2), looking for variables that maintained a positive correlation, considered between medium and strong in their combination. It can be seen that there is a linear relationship between Clicks and Reactions (rs = 0.755). Hence it is inferred that with each click there is a probability of obtaining a reaction, unlike the other variables implemented to calculate Engagement on Facebook*, like Comments (rs = 0.736) and Shares (rs = 0.612). One of the highest values is found in the Engagement and Reactions variables (rs = 0.906), with the understanding that there is a relation between the variables. So, it was considered important to explore the relationship between clicks and the formula that Facebook* uses to calculate Engagement (rs = 0.938).

We proceeded to give an interpretation of the determination coefficients obtained as a result of the three regression models (Table 5). First, we validated the variables using the values of the Spearman correlation coefficients (Fig. 2), looking for variables that maintained a positive correlation, considered between medium and strong in their combination. It can be seen that there is a linear relationship between Clicks and Reactions (rs = 0.755).

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Table 5. Regression models selected

Dependent variable	Independent variables	R^2	Error
User Engagement	Reach Type of content Source of content	0.679	61.52
User Engagement	Type of content Source of content	0.28	57.52
User Engagement	Clicks Reach	0.91	40.46

Throughout several iterations of adjustment, the best regression model with two independent variables was obtained. In the first one, two categorical variables (Type and source) were used together with Reach, obtaining an acceptable prediction of R2 of 0.679. The addition of categorical variables Source and Types did not show a significant difference in the models, so it was decided to implement them separately. The combination of the type and source categorical variables represents only an R2 at 0.28 of prediction. These experiments showed a relationship between the interaction on the contents between the number of Clicks and the Reach, visualized in Fig. 2.

Considering the result of the correlation of the variables available in the sample, it was detected that the sample had a linear relationship between Clicks and Reach with reactions. The selected model (equation 2) is more suitable because it has a lower margin of error and a 91% representativeness of the variables. Therefore, the selected regression model was model three in Table 5:

$$\text{User Engagement} = 1.7\ \text{Clicks} - 0.05\ \text{Reach} \quad (2)$$

The regression model defined (equation 2) obtained a coefficient of multiple determination (R^2) of 0.91 of influence of the independent variables. We worked with a p-value (2.2e-16) of less than 0.05. This means that the User Engagement regression model for a post that has not reached anyone or received clicks would be zero, obtained by moving the origin to the means of the predictors. The 1.7 coefficient of the clicks is associated with the opportunity of obtaining reactions during the interaction. While the 0.05 coefficient of the reach represents the decrement in Engagement for each click received by the post. It means that a person who is reached by the post, but who does not interact (clicks) causes a decrease in User Engagement. Meanwhile with the User Engagement calculation by the formula that implements reactions, comments and shares (Equation 1), the User Engagement had a value of 47. This is considered highly representative and allows predicting User Engagement in future posts based on clicks per post and people reached. To identify additional information, clustering was performed. From a test with the elbow method, four will be extended as the ideal number of clusters. Fig. 3 considers that the Engagement is made up of the interactions (Reactions, Comments, Shares) and the scope belongs to the total number of people who viewed on the publication.

Therefore, each of the dots represents an individual publication. The first group 1 (Red) is associated with the fact that they are publications that have less Interactivity and, as a consequence, there is less reach. In group 2 (Purple), there are behaviors close to group 1, but there is a publication that had a high Interaction rate in relation to the others, keeping the scope below one thousand, showing the main characteristic of this group. It had moderate interactions, but with a low reach. Group 3 (Green) is made up of those publications that had a reach of more than one thousand and less than

three thousand, regardless of the value of interactions they got. And finally, group 4 (Blue) has those posts that had a greater reach and are associated with higher Engagement.

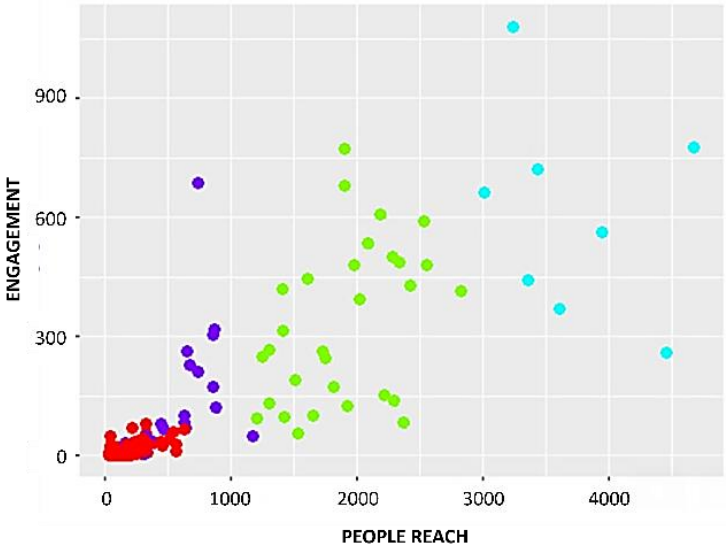

Fig. 3. Clustering by engagement and people reached

5. Discussion

In the qualitative analysis of unstructured data, relationships and groups are extracted that allowed us to take advantage not only of the descriptions obtained but also of the relationships. In this way, qualitative analysis supports the identification of the various types of relationships within data interactivity in the Facebook* social network. A study was carried out to create a regression model of the User Engagement percentage of a sample of posts about scientific dissemination on a Facebook* FP. According to RQ1, the multiple linear regression model with the highest precision was defined using only the number of Clicks and the Reach of the posts (equation 2). The calculation of User Engagement through a regression model has the advantage of adapting to the frequent changes that Facebook* introduces in the establishment of its variables (i.e., number of clicks, scope, impressions, number of comments, number of reactions, number of times a post is shared), which can influence the results as independent variables, unlike the Facebook* proposal based on count values. The regression models generated in this research provide an example of the dynamism that exists in the data generated within social networks, particularly Facebook*.

On the other hand, according to RQ2 using this same model, User Engagement increases preferably for posts with original content and with photos. From the perspective of a Facebook* user, the crucial factors to increase the levels of User Engagement are the interactivity of the users with the posts, in relation to the type of format they have. Finally, RQ3 allowed us to examine the relationships that exist between the metrics extracted from Facebook* involved in the regression model. Using Spearman correlation coefficients [18] provided a more qualitative interpretation of the determination coefficients obtained as a result, compared to proposals made with Pearson's correlation coefficients [29] and Poisson [16].

In the analysis and visualization of the variables of each publication, clustering was also applied as a data mining technique, demonstrating that self-produced content provides a higher Engagement.

6. Conclusions

The scientific community considers the analysis of social network data as a multidisciplinary research area that enables the creation, extension, and adaptation of methods [32] and data analysis models which empirically provide quantitative results using statistical methods [2]. For this reason, statistical analysis methods and qualitative analysis were used to establish a new method for calculating User Engagement on a Facebook* fan page for scientific dissemination content. The results of this research were the analysis of the posts, as well as a model using multiple linear regression with an accuracy of up to 91% (R2). According to the correlation values, it was shown that the number of clicks is the most effective metric compared to the usual interactivity metrics such as the number of comments, number of reactions, and number of times a post is shared.

For the roles involved in the management of social networks (Community manager or social media manager), the results of this research can be used as an idea of how to increase the level of User Engagement in posts by understanding the users interested in science topics. The output of the regression model can be used as a method to select the most fruitful or attractive post structures. Together with other Facebook* metrics, such as follower growth and new likes, they help to understand User Engagement and add precision by predicting the specific needs of each fan pages in the future.

The objective was to analyze the participation of the followers and the User Engagement in the content of the posts of a fan page with scientific dissemination topics. As future work, Disengagement (Negative Engagement) can be studied as a key consequence and its effect on the interactivity with the contents, as well as to determine whether the motivations are the same for the different categories of content types. In addition, the characteristics of the model obtained retain the scalability quality attribute and are adapted to other fan pages that are dedicated to dissemination or diffusion, validating its application and impact on decision-making.

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