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UTILIZING INTERACTIVE VECTOR GRAPHICS TO ENHANCE USER EXPERIENCE IN ENGAGING WITH COMPLEX USER INTERFACE DESIGN

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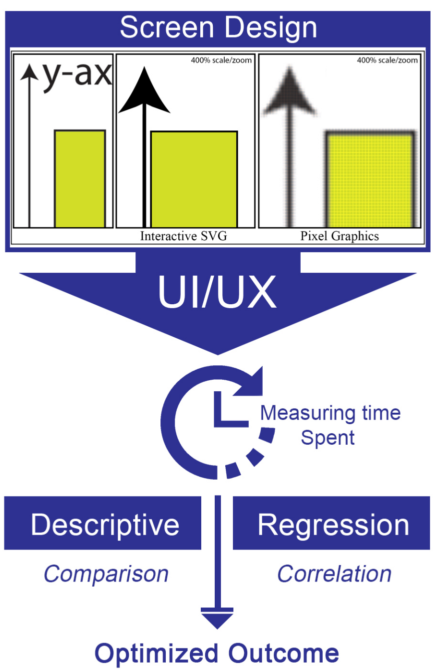
Graphical abstract



Abstract

In the shift towards the Fourth Industrial Revolution (IR4.0), there are a multitude of user interventions that are heavily dependent on screen-based content which are highly correlated with the Internet of Things (IOT). This has raised certain usability issues, primarily when utilizing pixel graphics in dealing with complex User Interface (UI) design on devices with smaller screen size. This paper addresses the delay in timing, as the main part of the usability issue, which is caused by the increased of user interaction in completing task given. This paper studies the conversion rate outcomes from pixel graphics to interactive Scalable Vector Graphics (SVG) as a solution in reducing user interaction thus enhancing overall user experience (UX). The research design focuses on 2 analysis stages, which starts with a comparison stage that is exploratory in nature, followed by a regression analytics as part of the usability testing. The comparative analysis utilizes A/B testing that is composed of a control group and a treatment group, which measures the time spent based on actions per-page, in determining the effect size of both pixel and vector graphics through specified observations. The regression analytics that follows through is explanatory in nature and measures the indirect effects of the time delay, in defining that there is a significant relationship between time spent against actions per-page. The findings contribute towards establishing a more impactful use of graphic format in the adaptation to UI design that maximizes UX outcomes, which defines effective usability towards conversion optimizations.

Keywords: Interactive Vector Graphics, Responsive Digital Layouts, Graphic Formats and Conversions, User Experience, User Interface Design

1.0 INTRODUCTION

Pixel graphics have always been used as the underlying graphic format for all screen-based devices. Though the resolution is capped at 72 pixels per-inch (PPI) for most digital contents, the output quality has always sufficed with regards to most application requirements, be it for broadcast [12], web-oriented [1], or even for sparse representations [8]. However, with the increased usage of the Internet of Things (IOT) as part and parcel in the shift to the Fourth Industrial Revolution (IR4.0), the increased production of smaller and more compact devices and gadgets that affects the limitations of screen sizes have led to usability issues especially when dealing with complex graphics user interface (UI) layout [2]. This is mainly due to the limitations in the technicality of pixel graphics, which causes abnormality such as pixelation when being scaled automatically by the device in use, in order to fit the dimensions of device screen sizes, as covered by various literatures [8][14][21][22]. Besides conforming to the issues of pixelation, there is also a main concern which relates to manipulation of graphic shapes, primarily the edge thickness as well as repositioning of these graphic shapes, that becomes difficult to interpret when forcefully scaled down. The pixel stippling parameters are limited and unable to be re-sampled in correlation to the scaling values. Therefore, it is limited in synchronizing with responsive screen layouts that relies on transformative interactions.

In confronting the many challenges and issues pertaining to managing pixel graphics within the UI, an alternative choice of using interactive SVG is highlighted to mitigate the complications to the mentioned usability issues. There are several literatures that converges towards the effective use of interactive vector graphics [23], primarily in the handling of visual communication matters. The use of vector graphics in replacing raster graphics have picked up exponentially over the years particularly for web-based content [24]. As screen space is limited, particularly for smaller devices, it is crucial that interactive SVG can address these problems in conforming towards space manipulation through coded modifications [3] in line with responsive layouts. Therefore, conditions can be prepared in customizing the parameters of the interactive SVG which converges towards the limitations of the device being used. Unlike pixel graphics, which is static in nature, and requires external manual input (such as a different application like Photoshop) by a user in order to manipulate its parameters for optimized outcomes.

The scope of this paper is not looking at the use of standardized icons, signs and symbols to replace text or shape contents as part of the UI design. Rather, it is more about utilizing customized SVG graphics in the construction of customized shapes and text in order to maximize user experience (UX) based on transformational manipulation of screen design, particularly in complex arrangements, such as infographics data. As such, the interactive SVG content can fully integrate with existing media queries coded functions as a method to 'transform' the UI when facing smaller screen parameters, as shown on Figure 1.

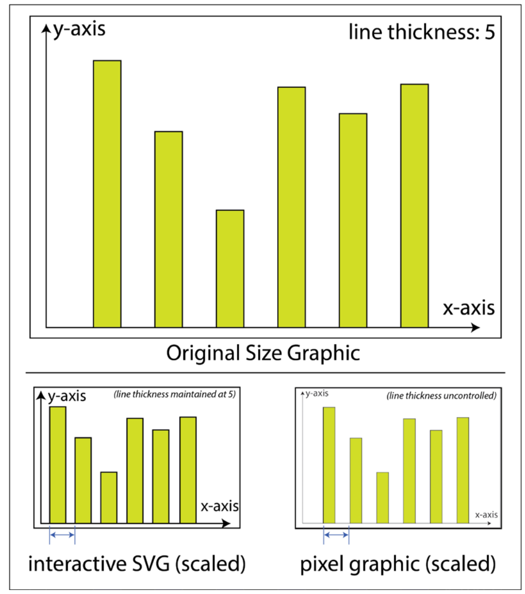


Figure 1 Comparison between the original graphic (top row) against the scaled down versions (bottom row), particularly the edge thickness and positioning of the graph shapes

From direct observation, the line thickness of 5-points is maintained when scaled down for the interactive SVG but not for the pixel graphics. As interactive SVG conforms towards vector graphics in nature, therefore avoids any form of pixelization as can be shown on Figure 2, unlike pixel graphics that are raster in nature. From direct observation in comparing both graphics, it is clear that the effects of edge thickness as highlighted from Figure 1 and re-positioning in pixel space provides clarity and better user engagement which supports usability, hence minimizes user interaction, which results in faster time in navigating through the pages.

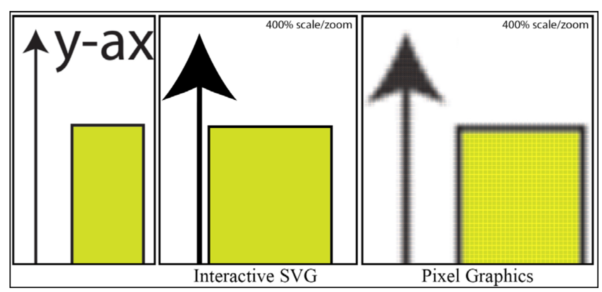


Figure 2 Comparing the pixilation as an effect of scaling

2.0 METHODOLOGY

Intrinsically, this paper intends usability test through 2 hypothesis testing; firstly, to compare the effectiveness of pixel graphics against interactive SVG based on time spent with reference to increased user interaction, and secondly to interpret the significance of the relationship between time spent and actions per-page. This leads to the construction of the conceptual model as shown in Figure 3.

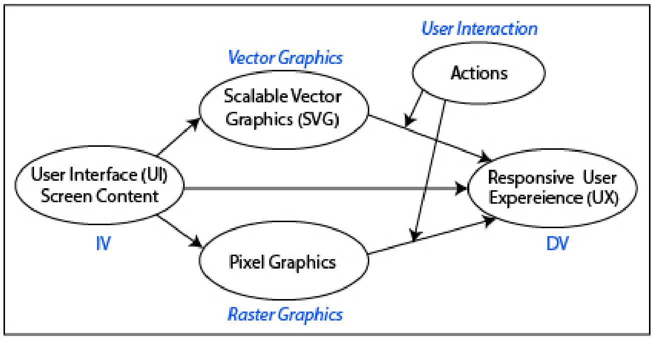


Figure 3 Conceptual Model

The first hypothesis which represents both the mediator variables, is denoted as H_{01} where there is no significant difference between pixel graphics and interactive SVG. This maps the alternate hypothesis denoted as H_{A1} where there is a significant difference between pixel graphics and interactive SVG, and to further prove that the interactive SVG is more effective. The second hypothesis, H_{02} measures the moderator variable, states that Actions per-page have no influence on time spent for navigation. The alternate hypothesis H_{A2}, represents that Actions per-page highly affects the time spent on navigation, thus dampens the UX outcomes.

In the data collection process, randomly selected participants comprising of TVET students from Klang Valley, central Malaysia were acquired to undergo the usability testing processes. The sampled participants involved in this study represents only the TVET student population, as the UI content is specifically designed towards the mentioned population, which maps to a customized Learning Management System (LMS) designed for the TVET community in managing progressive skills analytics. Therefore, with the coordination from TVET trainers that are part of the Industry Advisory Board (IAB) and members of the Department of Skills Development (DSD) officers, a total of 104 randomly selected TVET students within the first 3 levels of the National Qualifications Framework over the course of 4 months from April to July 2019. This comprise of certificate level TVET students only.

As briefly mentioned in the previous sub-section, the research design divides into 2 analysis stages, which addresses both hypotheses of the study. There is a total of 5 UI content (denote as pages) where each of the participants have to navigate through, using 3 types of devices: Desktop, Tablet and Mobile. The test was carried out in a controlled environment, where moderators are assigned to observe the participants. However, it is important to note that there was no conversation from the moderator to guide the user when attending to the pages. The job scope of the moderators is specific to observe and collect data. Before specifying directly to the individual components for hypothesis testing, this paper analyzes the descriptive statistics as part of the analytics to determine the distribution and basic normality of the data.

For the first hypothesis testing, the experimentation design conforms towards the A/B testing instrumentation to define the difference of timed outcomes of both groups. The A/B test calculates the effect size that measures time spent based on actions per-page, for each of the participants to navigate through the 5 UI content/pages for all mentioned devices. The sampled participants are equally divided into 2 categories, the Control Group and Treatment Group, regardless of demographics (age or gender) and skills level. Thus, it is 52 participants per-group. The control group utilizes the conventional pixel graphics as compared to the treatment group that uses interactive SVG. It is important to note that the context of the 5 pages are the same material for both groups, and the difference between the groups is the file format consisting of pixel graphics against interactive SVG. Therefore, the same participants are not used to undertake both the control group and treatment group to avoid biasness. This is due to the fact that anyone who undergoes the same contextual parameters for the second time will definitely have the experience to navigate through much faster. Due to the facilitating conditions of the A/B test, the analysis of data conforms towards the Paired-Samples T-Test, as the best fit to represent the mechanics of testing.

For the second hypothesis testing, the experimentation design conforms towards the linear regression analysis. As this is a summative test that follows through from the previous hypothesis testing, therefore the sampling range and sample size are similar. All the data collected from the observation are recorded and uploaded to a repository in an online shared drive which is listed in the appendix of this paper. This involves close observations that also records the user engagement of all sampled participants, primarily related to time spent per page and actions per-page. Each participant in the lab is observed by 2 moderators, with respect to capturing the elements of time and action. The analysis is computed through the SPSS software to process the test results, particularly looking at the significance of the weighted relationship.

3.0 RESULTS AND DISCUSSION

As mentioned from the previous sub-section, the experimentation stage was executed under a controlled environment, particularly in a computer lab therefore measures the engagement of the sampled participants. All the required devices for testing (desktop, tablet and mobile) were prepared beforehand, which includes both graphic versions of the UI content for the 5 pages of testing. As mentioned in the methodology, the descriptive analysis is carried out first to check the distribution and to confirm the normality of the dataset. It is imperative to ensure that normalized measures achieved statistical significance in order to execute the Paired-samples T-Test for the A/B test phase.

3.1 Descriptive Analysis

The descriptive statistics provides the paradigm for the A/B testing as well as the regression analysis. Standardized output for the descriptive statistics is shown in Table 1.

Table 1 Descriptive Statistics

			Statistic	Std. Error
Difference: Treatment - Control	Mean		-7.296	0.6754
	95% Confidence Interval for Mean	Lower Bound	-8.652	
		Upper Bound	-5.940	
	5% Trimmed Mean		-7.042	
	Median		-7.700	
	Variance		23.723	
	Std. Deviation		4.8706	
	Minimum		-23.8	
	Maximum		0.6	
	Range		24.4	
	Interquartile Range		6.6	
	Skewness		-.804	0.330
	Kurtosis		1.367	0.650

The scope of this paper is not looking at the use of standardized icons, signs and symbols to replace text or shape contents as part of the UI design. Rather, it is more about utilizing customized SVG graphics in the construction of basic shapes and text in order to maximize user experience (UX) based on transformational manipulation of screen design, particularly in complex arrangements, such as infographics data. As such, the interactive SVG content can fully integrate with existing media queries coded functions as a method to 'transform' the UI when facing smaller screen parameters, as shown on Figure 1.

From the observation shown in Figure 4, there is a single data point that looks to be an outlier, whereby the data point is far from the linear curve. After crosschecking with the actual data entry, the parameter of the value is within acceptance of the configuration, therefore the data point will not be removed.

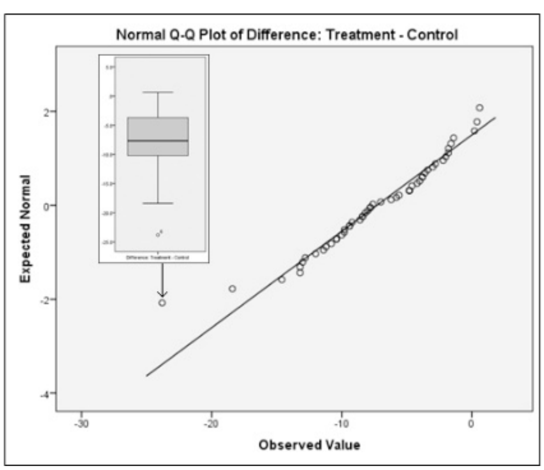


Figure 4 Q-Q Plot generated from SPSS

The next item within the descriptive statistics is the test for normality as shown in Table 2, particularly to review the significance of the output result.

Table 2 Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Difference: Treatment - Control	0.100	52	0.200*	0.953	52	0.040

The significance calculated is 0.04, which is less than the standard cutoff value of 0.05, so it indicates possibilities to reject the null hypothesis (H_{01}). However, further analyzes through the A/B testing utilizing the Paired-samples T-Test reinforces the final decision. The next section of this paper reiterates on the A/B test details.

3.2 Experimentation: A/B Test Analytics

As a quick reiteration, the A/B Test serves as the primary test for the experimentation in comparing the interactive SVG to pixel graphic, therefore, Multivariate testing is not within the scope of the paper. The data for both groups are captured and analyzed through SPSS, using the Paired-Samples T-Test, which provided the following results as shown in Table 3 and Table 4.

Table 3 Paired Samples Statistics and Correlations

		Mean	N	Std. Deviation	Std. Error Mean	Correlation	Sig.
Pair 1	Average Treatment Group	21.108	52	3.4317	0.4759	-0.032	0.820
	Average Control Group	28.404	52	3.3475	0.4642		

From Table 3, the mean for the treatment group is less than the control group, therefore signifying less duration was used in navigation through the pages leading to notion that interactive SVG being more effective choice. Elaborated analysis to support the notion can be reference to the results shown in Table 4.

Table 4 Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference: Lower	95% Confidence Interval of the Difference: Upper			
Pair 1: Average Treatment Group - Average Control Group	-7.2962	4.8706	0.6754	-8.6521	-5.9402	-10.802	51	0.000

From Table 4, the difference shown in the test results projected the t value of -10.802, which is very far from 0, therefore signifies a low p-value as shown based on the Significance 2-tailed result. Thus, based on the test information, it was decided to reject the null hypothesis as there is a statistically significant decrease of -7.3 between Means at a 95% confidence interval. The mean score can also be translated to the average time (in seconds), therefore the results showed that interactive SVG is about 7.3 seconds faster.

In summary, the t value of -10.802 with 51 degrees of freedom (df) is equivalent to the p-value of less than 0.005. As the p-value, only refers to estimate if the results are statistically significant, the effect size is calculated (through the mean value dividing by the standard deviation) as standardized measure of the magnitude of the observed effect, giving the result of 1.498. That is rather large effect size looking at a cutoff at 0.8 as commonly denoted in most literatures [4]. Therefore, it can be said that the interactive SVG have a large effect on time spent in navigating through the pages as compared to pixel graphics, therefore rejects the null hypothesis H_{01} that stated that there is no difference between both graphic formats.

3.3 Regression Analytics

The regression analysis is not geared to test the causality between IV to DV, but rather to identify that actions per-page which serves as a moderating variable affects the relationship between the interactive SVG and UX, based on time spent. This directly addresses the second null Hypothesis, H_{02} that intends to explain that the delay is highly caused by additional actions per-page rather than any other UX reasoning.

Firstly, with reference to the statistical information that was calculated in the previous sub-section, provided the mean score of 21.108 for the interactive SVG. In calculating the relationship, the option for Pearson Correlation was selected as the method of analysis. Pearson Correlation was selected as the distribution is normal (with reference to Table 1) thus conforms to a parametric calculation. Table 5 reviews the correlation analysis details.

Table 5 Correlations Analysis

		Average Treatment Group	TRM_Avg_FS
Pearson Correlation	Average Treatment Group	1.000	0.976
	TRM_Avg_FS	0.976	1.000
Sig. (1-tailed)	Average Treatment Group	.	0.000
	TRM_Avg_FS	0.000	.
N	Average Treatment Group	52	52
	TRM_Avg_FS	52	52

With reference to most standards [6], the correlations achieved should be greater than 0.3 and the output readings showed 0.976, therefore the result is highly correlated. The output data of the correlations analysis is supported with the normal P-P plot of regression as shown in Figure 5 and the scatterplot shown in Figure 6.

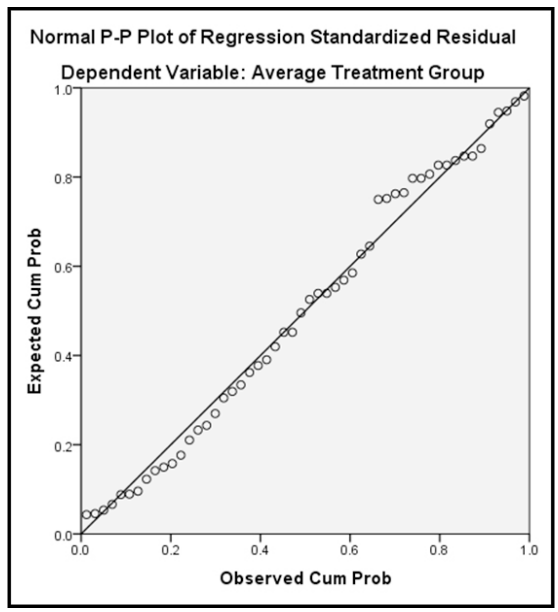


Figure 5 P-P Plot

It is important to note that the data points all lined up close to the regression line, and there are no outliers in this graph.

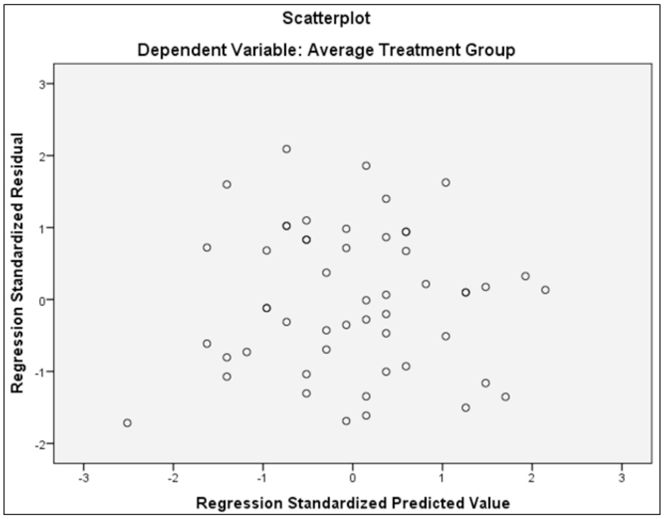


Figure 6 Scatterplot

All the standardised residual points in the scatterplot are within the expected mean range from -3 to 3. The actual data can be clearly reviewed in Table 6 stating the minimum and maximum value between -1.2848 to 1.5663, thus confirming that the residual plots indicate a good fit. In addition, the Cook's distance score is less than 1.0 which reinforces the case that there are no obvious outliers.

Table 6 Residuals Statistics

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	12.685	28.301	21.108	3.3506	52
Std. Predicted Value	-2.514	2.147	0.000	1.000	52
Standard Error of Predicted Value	0.104	0.283	0.141	0.041	52
Adjusted Predicted Value	12.899	28.289	21.112	3.3439	52
Residual	-1.2848	1.5663	0.0000	0.7414	52
Std. Residual	-1.716	2.092	0.000	0.990	52
Stud. Residual	-1.854	2.124	-0.003	1.011	52
Deleted Residual	-1.4995	1.6146	-0.0046	0.7737	52
Stud. Deleted Residual	-1.901	2.204	-0.002	1.024	52
Mahal. Distance	0.005	6.319	0.981	1.295	52
Cook's Distance	0.000	0.287	0.022	0.043	52
Centered Leverage Value	0.000	0.124	0.019	0.025	52

Finally, judging from the ANOVA table (Table 7), shows that the regression is significant therefore signifies the possibility to reject the null hypothesis H_{02}.

Table 7 ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1(SVG)	Regression	572.560	1	572.560	1021.074	0.000
	Residual	28.037	50	0.561		
	Total	600.597	51			

The significance is further reinforced with the data displayed in Table 8 that shows a high R Square value of 0.953. This means that 95.3% of the variance in the dependent variable over all functioning is explained by the measurement. Most literature sets the minimum R Square value at 0.3 [7], therefore the final result achieved in the analysis is rather impactful in comparison, which relays the decision to reject the second null hypothesis, H_{02}, which states that Actions per-page have no influence on time spent for navigation.

Table 8 Model Summary

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1(SVG)	0.976	0.953	0.952	0.7488	0.953	1021.074	1	50	0.000

The following sub-section discusses the final results of the paper, particularly in answering the hypothesis and reflects back onto the problem statement.

3.4 Critical Evaluation of Results

For the results obtained from both the A/B Testing and the Regression Analysis, the conclusion to reject both the null hypotheses, H_{01} and H_{02}, were confirmed. The aim of the research is achieved in validating that the interactive SVG is more effective towards conversion rate optimization in engaging the problem statement, therefore provides towards a better overall UX. The conversion rate relies on the data from the analysis. Therefore, the informed decision to reject the null hypotheses were made based on the measures from the data. It is not within the scope of this research paper to include qualitative reasoning in support of the UX that explains the engagement rate, which measures user perceptions and impressions.

However, what is clearly noticed from the observation is that the page navigation actually gets slower when switching to smaller devices, which naturally requires more actions per-page. This realization was highlighted during the observation phase, but the limitations of this research is not specific to only measure small screen sizes or devices, but all of the mentioned components, namely desktop, tablet and mobile. Specified devices will be considered on a future research that includes qualitative data analytics.

4.0 CONCLUSION

With the exponential increase of digital devices consumed in the world today, it becomes more difficult to design UI that conform towards customized parameters in order to maximizes UX. From the A/B Testing and the Regression Analysis, the results clearly showed that minimizing time spent in interpreting graphics content does enhances usability in the efforts of maximizes UX. Transformative abilities within the design is essential to cater for the need of change, particularly graphic file formats that is primarily used for interactive screen content. Though this research focused in measuring the conversion rate based on time spent while regressing on user interaction, there are other school of thought in proposing that UI design can be enhanced based on psychological reasons pertaining to user engagements, that leads to impressions rather than new technology. Data driven results is best for optimization, but engagement is best for community building and brand loyalty instead. Design towards optimization is an ongoing endeavor that prioritizes effect communication with the user in enhancing impactful user experiences. From a qualitative perspective, possibilities of future research that relates to user engagement can measure other vanity metrics, such as retention rates or engagement rates that further contributes to the embitterment of UX. Another area that see a vast development utilizing SVG graphics branches into the realm of 3D design.

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