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Scope: The Journal of Management and Engineering Integration (JMEI) is a double-blind refereed journal dedicated to exploring the nexus of management and engineering issues of the day. JMEI publishes two issues per year, one in the Summer and another in Winter. The Journal's scope is to provide a forum where engineering and management professionals can share and exchange their ideas for the collaboration and integration of Management and Engineering research and publications. The journal will aim on targeting publications and research that emphasizes the integrative nature of business, management, computers and engineering within a global context.

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The Journal Editorial Team would like to thank the reviewers for their time and effort. The comments that we received were very constructive and detailed. They have been very helpful in our effort to continue to produce a top-quality journal. Your participation and timely response are very important for the success in providing a distinguished outlet for original articles. In this issue we included Keywords, and the dates the publication was submitted and revised in an effort to achieve a higher standard for publication and increase the impact of the journal.

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Does a Municipality's Wellness Affect its Business Growth?

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Abstract

This study focuses on the health of a given population to determine if health indicators can be used as a predictor of business growth in a geographic region. A study that was focused on the wellness in a firm, concluded: "that firms can increase operational productivity through socially responsible health policies that improve both workers' wellness and economic value" (Gubner et.al., 2018). That study was typical of most papers on wellness. It analyzed the impact of a corporate wellness program on worker productivity. While interesting, it was severely limited in scope as it was based on only one firm.

Most studies that examined the factors that contribute to growth in major areas are confined largely to cities and cite factors that do not include wellness. The factors most often mentioned are a city's: (i) natural resources surplus; (ii) industrialization and commercialization; (iii) development of transport and communication; (iv) economic pull; and (v) educational and recreational facilities. Other factors mentioned include a well-developed infrastructure, good quality, available human capital, and a decent ecosystem. Wellness is normally absent as a factor or is rarely mentioned. This study is different. It is focused on the role that wellness could play in the economic growth of a major area in the country. That major area is a Municipal Statistical Area (MSA) in the United States of America (USA). An MSA is not limited to a city, but may extend from one major city to several adjoining industrial areas in close proximity. Thus, this study takes a much more robust, macro-oriented approach.

The research used multiple-regression modeling. It determined that there may well exist a positive relationship between the wellness of an MSA and the percent increase in business establishments in that MSA. The yearly percent increase in business establishments in an MSA was used as the response variable i.e., the business growth in an MSA. Two control variables were necessarily employed in the study to improve accuracy. The first was whether the MSA was in a Right-to-Work (RTW) state. The second was if the MSA existed in the Rust Belt (RB) area of the USA.

A second research portion of this study used different statistical methods (ANOVA and MANOVA) to examine the impact of wellness on business growth and two additional explanatory variables (i.e., unemployment and annual salaries in an MSA). This analysis validated that increased MSA wellness is a driver variable that increases business growth and leads to lower unemployment and higher annual salaries in an MSA.

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Keywords: Metropolitan Statistical Area (MSA), Right-To-Work (RTW) statutes, Rust Belt (RB)

1. Background

The World Health Organization defined health in 1946 as "a state of complete physical, mental, and social wellbeing and not merely the absence of disease or infirmity" (Keynes, 2015). Factors known to influence the health of individuals include family history, lifestyle, economics, and social conditions. In addition, wellbeing (i.e., wellness) is a general term used to describe a person's social, emotional, spiritual, or medical state. Sometimes the term is used to describe a state of inner happiness. High well-being means that, in some sense, a person's experience is positive, while low well-being means it is more downbeat or pessimistic (Ibid). Health and well-being are often overlooked as contributing to Business Growth in major areas of the United States.

More recently, health professionals and leaders around the globe have shed light on the impacts of employee health and wellbeing, and how the two can be an effective means of understanding economics and long-term costs in a region. Although initially, cost minimization was the sole driving force behind the corporate interest in health, many companies now better understand the total impact on their firms of their employee's health and wellbeing. When organizations invest in their employees' wellbeing, they reap significant reductions in costs, which increases in value over time. Healthier people have been shown to (a) take significantly fewer sick days; (b) have a lower cost differential in disease burden and associated costs relative to those who struggle; (c) are more likely to be engaged in their workplaces; (d) be more productive and cost-effective in their jobs. Additionally, they help to improve their communities and the links of their organizations to their communities (Rath & Hartner, 2010).

This study is not aimed at the firm, but at MSAs in the USA. It provides an analysis of wellness as it pertains to businesses in the over 100 MSAs in the USA. Specifically, it was intended to determine if wellness could be used to assist in predicting Business Growth in an MSA. As wellbeing could be an extremely important attribute in both the public and private sectors, there were two objectives for determining the value of wellness in improving: (a) the competitive advantage; and (b) business strategic analysis in both sectors.

2. Literature review

The study of health and wellbeing and its impact on employee productivity has been a research topic for decades. While there is evidence of early corporate interest in and adoption of workplace health and wellbeing in the late 1960s and 1970s, the trend appears to have accelerated a decade later. Examples include such things as companies requiring physicals and X-rays for employment. The 1980s appear to be when companies began to show a true interest in workplace wellbeing and employee health. Insurance costs were on the rise, the health craze of the era was in full swing, and wellbeing was beginning to infiltrate radio, television, and homes across the country. For example, the proliferation of workout videos by popular TV personalities like Jane Fonda was gaining traction in the country. In 1984, the Boeing Company declared that it is a company's responsibility "to provide the cleanest, safest and most healthful environment possible for its employees". While the company started small by designating restricted areas for smoking, by 2009 the entire Boeing workplace was tobacco-free (Vesely, 2012).

Higher levels of fitness, defined as not being obese, being active, and being at or above the norm for Cardiovascular Research Foundation (CRF) criteria, are associated with a host of positive outcomes. From a health outcomes perspective, reduced risk for preventable deaths, cardiovascular disease, diabetes, certain cancers, back pain, and high cholesterol, as well as improved mood states and job satisfaction have been associated with employee fitness levels (Pronk, 2015). Fitness has

also been correlated with wealth-related outcomes such as greater (5%-to-10%) worker wage increase (Kosteas, 2012), increased overall family earnings (Conley & May, 2005), lower debt, and lower long-term unemployment (Pronk, 2015). Business-related outcomes include relationships between fitness and reduced absenteeism, productivity loss, healthcare costs, turnover, short-term disability, and improved employee job satisfaction and work performance (Pronk, 2015). As was stated by Dee Edington, founder of the Health Management Research Center at the University of Michigan, when describing some of the early studies around health and the workforce, "After 30 years, we know the real advantage is helping healthy people stay healthy" (Vesely, 2012). Corporations and businesses alike followed the trend, recognizing the inherent benefit in what seemed intuitive i.e., a healthy employee is a productive employee and wellbeing is the key.

Numerous examples exist that demonstrated that individual health and well-being can be important to strategic and financial decision-making. A study conducted by Katherine Baicker, professor of health economics at the School of Public Health, Harvard University, did a critical meta-analysis of the literature on costs and savings associated with such programs. She reported that medical costs fall by about $3.27 for every dollar spent on wellness programs and that absenteeism costs fall by about $2.73 for every dollar spent (Baicker, 2010). This return on investment suggests that the wider adoption of such programs could prove beneficial for budgets and productivity, as well as health outcomes. Further evidence can be seen in human resources consultancy. Mercer's 2012 survey of 2,809 employers found that nearly half of all large companies have added incentives and penalties to boost participation in wellness programs, and 18 percent link incentives with health outcomes (Vesely, 2013).

Another twist in current research around employee wellbeing and its impact on productivity focused on the comparison of lost productivity due to chronic illness versus lack of wellbeing. Having a chronic condition has been shown to have had a significant impact on workplace productivity. However, in a recent study conducted by the Journal of Occupational and Environmental Medicine, research demonstrated that an employee's wellbeing is a more important contributor to on-the-job productivity than their chronic disease status (Agee & Madison, 2014). The study, entitled "Comparing the Contributions of Well-Being and Disease Status to Employee Productivity", was a two-year study of 2,600 employees that showed employees with higher well-being demonstrated greater workplace productivity, regardless of whether they suffered from chronic conditions. In addition, well-being was more important than chronic disease or demographic factors in defining how productive a person would be in any given year (Gandy, 2014).

Gubner et.al. produced a study that concluded: "firms can increase operational productivity through socially responsible health policies that improve both workers' wellness and economic value and provided a template for future large-scale studies of health and productivity". That paper investigated the impact of a corporate wellness program on worker productivity using a panel of objective health and productivity data. However, it was limited to only 111 workers in five laundry plant in one firm (Gubner et.al., 2018). Qaisar studied the relationship between perceived productivity levels and employee wellness. Data was collected using scales comprised of exemplary items to measure selected variables. A sample of 108 managers from public sector anti-corruption and regulatory organizations was collected. Their results showed a significant positive relationship between organizational productivity and worksite wellness measures, employee wellness, and employee productivity (Qaiser, 2018).

While important, many such studies were severely limited or overly focused on the wellness within a firm. This study is intended to address the wellness of an entire community. A more macro-oriented study is needed that would look at wellness within an entire economic area, specifically

within an MSA. **This study seeks to primarily investigate the impact of Wellness on Business Growth in a USA MSA.** Most articles in the literature address factors that may contribute to the economic growth of only cities and not municipalities that include cities and outlying economic areas closely related to a city. A typical example of such a study suggested that the economic growth of a city is a function of (i) Surplus Resources; (ii) Industrialization and Commercialization; (iii) Development of Transport and Communication; (iv) Economic Pull of the City; and (v) Educational and Recreational Facilities (Mohita, 2018). Other factors mentioned in other studies include a well-developed infrastructure, good quality, available human capital, and a decent ecosystem. Wellness is normally absent as a factor in economic growth or is very rarely mentioned. However, this study focuses on wellness in USA MSAs which includes a city and also extends to several adjoining economic areas close to a city. An example is MSA 10580 which includes Albany-Schenectady and Troy, New York. (Bureau of Labor Statistics, 2015).

Gallup performed a decade-oriented baseline study in 2012 and 2013 that included data on wellness in municipalities. Gallup and Sharecare, 2012, created this study (the Gallup-Sharecare Global Well-Being Index) to measure well-being worldwide. This Gallup data study included 187 MSAs in the United States and considered multiple factors for wellness. It drew on the panel data that had been assembled over the 2012–2013-time frame. Gallup reported findings from the Gallup-Sharecare Well-Being Index in weekly, monthly, quarterly, and yearly aggregates, and by region, state, and community, as appropriate (Gallup, 2014). The data used in this survey were the Gallup 2012- 2013 yearly data results.

The specific factors used by Gallup to determine an overall wellness index (W_I) were as follows: % Obesity, % that workers exercised frequently, % that ate produce frequently; % that were Smokers; % With daily stress: and lastly % Uninsured. This data provided an excellent foundation to meet the goals that were set for this study i.e., to determine if health indicators can be used as a predictor of Business Growth in a geographic region. The Gallup study produced results that were significant with an overall R^2 of 72% and an F of 78.05. It provided an overall model which included all the elements for wellness shown in the previous section. The Wellness formula from the study is shown below:

Wellness = 63.50698 – 0.11904 (% Obese) + 0.14 766 (% Exercise Frequently) – 0.06060 (Eat Produce Frequently) -0.24312 (% Smoke) + 0.14719 (% with daily Stress) – 0.10706 (% Uninsured)

3. Data

While every effort was made to ensure data quality and integrity, there were some minor limitations to the data used in this study. These limitations included:

1. The number of USA MSA's in the Gallup study was limited to 186 locations (only one outlier in the data had to be eliminated)
2. The wellness index was taken from the data used in the Gallup study 2014 *U.S. Community Well-Being Tracking* [Data File], http://gallup.com/poll

3.1. Major objectives/hypothesis

This research paper seeks to discover if economic growth in a USA MSA can be influenced by the wellness measure in the MSA. In addition, two other variables were also considered to be

worthy of consideration and deemed to be useful as control variables. The first was whether the MSA existed in one of the 28 Right-To-Work (RTW) states. A second variable was whether the MSA was in a Rust Belt (RB) state. A priori knowledge of what factors drive increases in business growth would be invaluable to both firms and governments in the MSAs. Private firms could leverage such information as input for establishing a new or relocated facility. Governments could use this information for strategic planning purposes in attracting new businesses to locate in their municipality.

The Null Hypothesis*:* There is no relationship between the Business Growth in an MSA and its wellness after controlling for the effects of the other variables (RTW and RB)

H_0: $\beta_1 = 0$

The Alternate Hypothesis: There may well be a relationship between the Business Growth in an MSA and its wellness after controlling for the effects of the other variables. (RTW and RB)

H_A: $\beta_1 \neq 0$

3.2. Research design and methodology

Table 1: Variables in the model

Variables	Description
Y - Dependent Variable - Percent Change in Business Establishments or Business Growth (BG)	This is a scale variable that measures the percent change in the number of business establishments in the MSA of interest between 2012 and 2013.
X_1 - Wellness (W)	This is a scale variable that measures the healthiness of the residents of the MSA of interest in 2012.
X_2 - Right-To-Work (RTW)	This is a binary control variable set equal to 1 if the state where the MSA is located was a RTW state in 2012, and 0 otherwise
X_3 - Rust Belt (RB)	This is a binary control variable set equal to 1 if the MSA of interest is in the RB, and 0 otherwise.

The multiple regression model is expressed as $BG = \beta_0 + \beta_1 W + \beta_2 RTW + \beta_3 RB + \varepsilon$, where BG is the dependent or response variable and W is the explanatory variable. RTW and RB are control variables. Table 1 includes a description of each of the variables. If the model results in a rejection of the Null Hypothesis, it can be assumed that wellness could very well be a factor in the establishment of new businesses in an MSA. Also of note is that ε accounts for the random variation in the data (Texas A&M University Department of Statistics, 2013).

3.3. Analysis and Results

Table 2 are tabulations of the descriptive statistics for the two-scale variables in the study i.e., BG, the percent change in Business Establishments (a surrogate for Business Growth in an MSA), and W, the wellness in an MSA. Table 3 is a tabulation of the descriptive statistics for the two binary variables – RTW and RB. These statistics were derived using the 186 observations available from the Gallup Data. The Original data set had 187 observations, which was reduced to 186 (one

outlier was removed i.e., Springfield, MO). The observed value of Springfield wellness was 3.50 standard errors larger than the predicted value. Such a major departure from the mean was extreme and therefore, Springfield was treated as an outlier. Table 3 contains the Descriptive Statistics for the Binary Variables while Table 4 has the results of the Multiple Regression.

Table 2: Descriptive Statistics for Scale Variables (n=186)

Variable	Mean	Std. Dev.	Min.	Q1	Median	Q3	Max.
% Change in Business Establishments (BG)	0.52	0.93	-1.62	-0.10	0.50	1.17	3.38
Wellness (W)	66.30	2.14	59.50	64.90	66.30	67.40	71.40

Table 3: Descriptive Statistics for Binary Variables (n=186)

Variable	Value = 0	Value = 1
Right-To-Work (RTW)	92 (49.5%)	94 (50.5%)
Rust Belt (RB)	142 (76.3%)	44 (23.7%)

The estimated regression equation below was derived from the model as follows: BG = -11.5 + 0.18W + 0.23RTW – 0.6RB (see Table 4 for all regression statistics)

Table 4: Multiple regression statistics

Variable	Estimated Coef.	Std. Error	T-Value	P-Value
Constant	-11.45	1.85	-6.17	0.00
W	0.18	0.03	6.54	0.00
RTW	0.23	0.12	1.93	0.06
RB	-0.60	0.14	-4.26	0.00
F-Value = 26.71		P-Value = 0.00		Adjusted R^2 = 29.42%

Based on research and analysis conducted, this study rejects the Null Hypothesis (H_0). In so doing, this analysis indicates that overall wellness may very well have an impact on the BG of a given MSA. It should be noted that both RTWs and RB were indicators, control variables. RB had a negative coefficient and was significant (P-value of 0.00) in affecting Wellness. Lastly, the F-Value was significant in the model, and the adjusted $R^2$was just under 30%. Thus, 29.4% of the variation in BG is explained by W.

3.4. Further analysis

Additional data were available to take a more in-depth look into what else may be affected by Wellness. Such data was available for Unemployment, Weekly earnings, Entrepreneurship, Homeownership, as well as the area growth in businesses. Upon closer analysis, data was found to be only present in enough quantity to analyze the first two variables. This data was present in the Gallup's (2013) Wellness Index (1.5K data points); (b) the Bureau of Labor Statistics (2012 – 2013) Annual Salary (1.5M data points); (c) Unemployment (1.2M data points); and (d) the Census Bureau (2012 – 2013) Establishment count (27.5K data points).

A second null hypothesis is $\boldsymbol{H_0}$: $\boldsymbol{\mu_1 = \mu_2 = \mu_3 = \mu_4}$ where μ_x = the multivariate mean for each of the response variables (unemployment rate, annual salary, and the percent of change in the number of new establishments). The value *x* represents each of the four quartiles for the treatment variable, the wellness index.

The second alternative hypothesis is $\mathbf{H_1}$: $\mathbf{at\ least\ one\ \mu_x\ is\ different.}$

Focusing on minimizing a Type I error, it was decided to use another approach in analyzing the data. Thus, it was decided to employ a Multiple Analysis of Variance (MANOVA) statistical analysis. This involved four Wellness Quartiles ($\boldsymbol{Qx}$) as treatment variables and three response (dependent) variables i.e., Unemployment, Annual Salary, and Business Growth. The first treatment variable (Q1) was the average of all values that occurred in Municipalities with the lowest values (in the first 25% quartile); Q2 was the average of all values that occurred in Municipalities with the next lowest values (in the second 25% quartile) etc. The results were as follows in Table 5:

Table 5. MANOVA for wellness quartiles

s = 3	m = -0.5	n = 89.5				
Criterion	**Statistic**	**Approx. F**	**Num**	**Denom**	**P**	**F Crit**
Wilks'	0.59154	11.788	9	440	0.000	1.90116
Lawley-Hotelling	0.68575	13.69	9	539	0.000	1.89724
Pillai's	0.41126	9.691	9	549	0.000	1.89692
Roy's	0.67876					

The approximate F for the model: Wilks', Lawley-Hotelling, Pillai's, and Roy's F values all significantly exceeded the required F-Critical values. Also, the P-values were strong for each of the response variables. Type-I error was only .05 and acceptable for the study. Thus, the second Null Hypothesis (H_0) was rejected i.e., the ANOVA/MANOVA analysis demonstrated that wellness may well have an impact on Unemployment, Annual Salary, and Business Growth. This impact was in the expected direction i.e., Unemployment decreased in the case of MSAs with improving Wellness, while Annual Salary and Business Growth both increased with improving Wellness. In the case of Business Growth, this confirmed the results of the earlier regression model covered earlier in this paper.

Three Analysis of Variance (ANOVA) tests were then applied to get a better picture of what was happening in the four quartiles. In each of the three cases, there was one treatment or independent variable (W for each of the four Wellness Quartiles) and only one response variable at a time (a dependent variable such as unemployment rate). The resulting graph of Wellness treatments for four Wellness Quartiles resulting in different Unemployment percentages are shown below in Figure 1 (ANOVA 1). It is noted that Unemployment decreases rapidly as Wellness improves from Quartile 1 (Worst Wellness) to Quartile 4 (Best Wellness) i.e., Unemployment decreases from 8.7% (Q1) to 6.4% (Q4). Figures 2 & 3 show the graphs for ANVOVA 2 (Annual

Salary) and ANOVA 3 (BG). In Figure 2 (ANOVA 2) Annual Salary increases significantly as Wellness increases from Quartile 1 ($40,000/year) to Quartile 4 ($48,000/year). Lastly, Figure 3 (ANOVA 3) shows that BG (% of growth in new establishments) also improves significantly from - .10 % (Q1) to + .90 %. (Q4). Also noted is that all the P-values were strong for all three of the response variables. While a post-Hoc test is sometimes used after a MANOVA analysis to show where the specific independent variable differs, the three ANOVA tests demonstrate the behavior of these variables. For this reason, it was decided that a post-Hoc test was unnecessary.

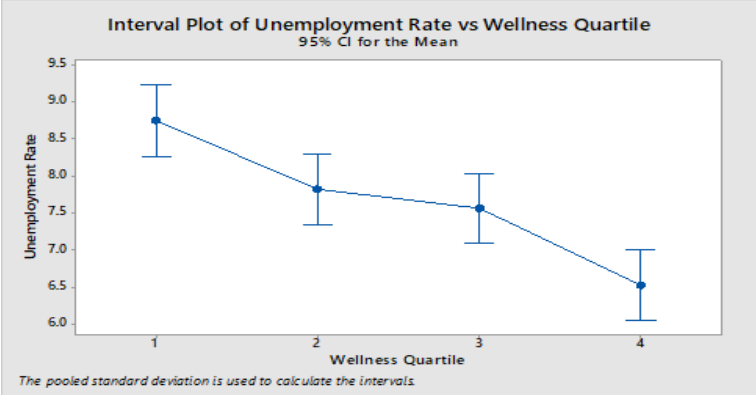

Figure 1. ANOVA 1 Wellness → Unemployment

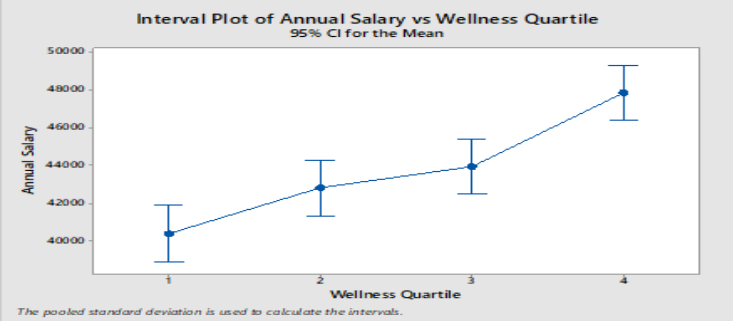

Figure 2: ANOVA 2 Wellness → Annual Salary

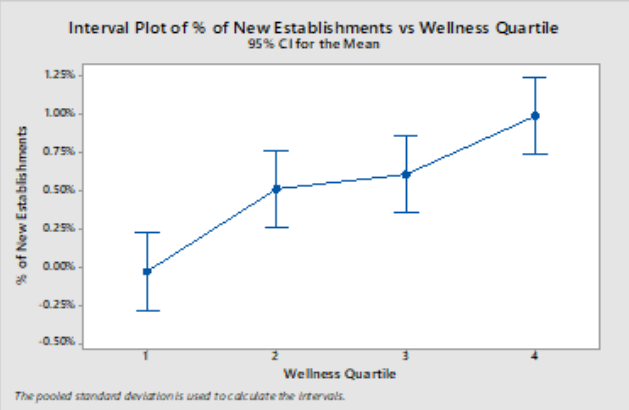

Figure 3: ANOVA 3 Wellness as % Change of New Establishments

4. Conclusions

Wellness was shown to be a very significant variable as it pertains to the Business Growth of an area (MSA). The Rust Belt control variable was negative, indicating that RB states carry a negative contribution to the business growth in an MSA. A business looking to invest in a given MSA or determining whether to relocate its operations should focus on wellness as a significant factor. Wellness should also be considered by municipalities looking for a competitive advantage over other locations. Investment made in wellness by both business and local governments in an MSA may well interact to provide a significant economic gain in an MSA. This study posited whether wellness significantly impacted business development in the United States today This research has the potential (if applied properly) to improve decision-making in two main business areas: Competitive Advantage and Strategy Analysis.

Competitive Advantage: To retain businesses, MSA governments should pay close attention to ensure that they are doing all that they can to enhance wellness in their respective areas. To be competitive in their industry, a firm must be able to build a sustained, competitive advantage. To be able to attract investment in a given MSA: (a) Existing firms in an MSA must focus efforts on continuous evaluation of their employee's wellness and (b) Firms must constantly seek to improve wellness in their areas to ensure that they can sustain a competitive advantage against other businesses.

Business Strategy Analysis: Governments need to understand what factors need to be considered when performing city planning and include wellness in their analysis. They should perform benchmarking in wellness against top-rated MSAs. In seeking to maximize a company's value, a firm must consider the health and wellness that exists in any MSA in which they operate. In determining whether to invest further in a location or to move operations to a new MSA, firms must employ due diligence and adequate analysis as it pertains to wellness. Such analysis should: (a) consider MSA wellness in its strategic planning for location/relocation activities; and (b) ensure they firms have significant wellness present in any proposed operation that they are considering before deploying to an MSA. This is necessary so that they will be able to attract businesses away from incumbent businesses, as well as to counter new threats.

Lastly, this study concluded that municipalities (and firms) looking to compete must consider health and wellness as a significant contributor to their unemployment rates, local wages, and the number of business establishments. In this way, wise decisions can be made on competitiveness, benefits, and long-term stability.

5. Recommendations

Despite providing strong evidence that wellness needs to be a major factor in deciding where to locate a future business, it should be noted that the regression model only explained 29.42% of the variation in the Y variable (Business Growth in an MSA). This leaves approximately 70% of the variation in Y unexplained. This seems plausible in that other logical variables could also contribute to Business Growth in an MSA e.g. (i) Surplus Resources (ii) Industrialization and Commercialization (iii) Development of Transport and Communication (iv) Economic Pull of the City (v) Educational and Recreational Facilities to name some.

Future research needs to focus on exactly what are these other undiscovered, explanatory variables, as well as the impact of each. If a few other driver variables could be discerned and then proven to produce an improved, parsimonious model, it would be a major contribution to the literature on what is affecting Business Growth in the MSAs that comprise the economic grid in the United States.

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School Vouchers for Greater Educational Equity

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Abstract

Providing public funding to parents to pay children's tuition at private and religious schools has been a matter of debate over the last three decades based on claims such as the lack of accountability in private schools, an increase in segregation, and the fact that it contradicts the principle of the separation between church and state. Such concerns are legitimate, but they need to be discussed considering the new literature that proves the efficacy of private schools, both religious and non-religious, in terms of student achievement, test results, and graduation rates. A thorough look at the test results revealed by the National Assessment of Educational Progress (NAEP) over the last decade indicates that students' scores in private schools are higher than their peers in public schools. NAEP results and the recent empirical studies conducted in states like Florida, Wisconsin, and Washington DC confirmed that the voucher system works well. This information provides compelling evidence that policymakers need to review the private school voucher policies. Hence, this article highlights the efficacy of school vouchers based on recent empirical studies and the academic results of the students enrolled in school-voucher programs. The available data assures that there is no point in depriving students of their right to choose private or religious schools as their peers who choose charter and magnet schools.

Keywords: equity, school-vouchers, private schools, religious schools, non-religious schools

1. Statement of position

Preventing students from their right to school choice when it comes to private schools, especially the religiously affiliated ones, is a real threat to American values, in general, and educational equity in particular. Wolf (2008) defined school voucher programs as "an arrangement whereby public funds are made available to qualified parents to cover some or all of the expenses associated with enrolling their child in a participating private school of their choosing" (p. 415). The law that grants public funding for public schools and all types of school choices except private schools especially religiously affiliated schools can be described as a discriminatory law that arose from a discriminatory purpose aimed at specific or the entire religious beliefs. This law is against the great core of American values and cultural gains like freedom and democracy. Legislators should support the students attending private schools to protect their right to school choice by enacting a fair public funding policy for the educational private sector. So, policymakers need to rethink the current policies which prevent 10% or more of the United States (US) children from attending private schools with public funding. Such policies violate the concepts of equity and equal opportunity in education.

In 2019, in his second State of the Union Address, President Trump proposed a new school choice legislation. The proposal was in congruence with what Wong (2018) has reported regarding "a shift in

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public opinion in favor of school choice". Although the proposal had no details, DeVos, the US Education Secretary, praised Trump's proposal and described it as a call for education freedom (Klein, 2020). However, several questions may arise: what challenges may have prevented private schools from being a part of the school choice in the past; does the voucher system work well?; and is it time for the private and religious schools to be a part of school choice programs? Secretary DeVos, who was considered one of the greatest supporters of school choice, promised to work on federal legislation to expand private school choice since she came into office (Barnum, 2017). However, the Trump administration with Betsy DeVos could not bring new life to the educational voucher system.

2. Literature review

According to Catt and Rhinesmith (2017), the National Center for Education Statistics (NCES) conducted a study in 2012 to measure parental satisfaction of students attending private, charter, and public schools. The survey findings showed that parents whose children attended private schools were the highest to report they were very satisfied, followed by parents whose kids enrolled in charter schools. Whereas parents of public schools were the least to say they were very satisfied. NCES reported that 5.9 million out of 65.6 million students who attended prekindergarten through grade 12 schools enrolled in private schools in Fall 2018 (Catt & Rhinesmith, 2017). The report has also stated the percentage of students enrolled in private schools increased from 9.7% in Fall 2013 to 10.2% in Fall 2015. Such an increase in enrollment continues while it is difficult for students of low-income families to afford private school tuition. The Milwaukee voucher system is a prominent example of student success when parents could choose their children's schools. Milwaukee private school vouchers helped secure a safe place for the kids of the African American community to have the education they need (Sanchez, 2017).

2.1 Historical perspective

The debate for funding private schools goes back to the time of the founding of the United States. According to the National Conference of State Legislature (NCSL), school-voucher programs were implemented more than 140 years ago when Vermont and Maine provided public funding to private schools in 1869 and 1873, respectively (Cunningham, 2016). The two states supported private education as a form of compensation to the students in the rural areas that did not have public schools. According to Wolf et al. (2013), prominent public figures like Thomas Paine, John Stuart Mill, and Milton Friedman were great advocates for school vouchers. Thomas Paine advocated the idea that the government should finance private schools since 1791. While John Stuart Mill proposed school vouchers as an obligation of the government to help parents choose the type of education they prefer for their kids. In 1955, Milton Friedman argued the concept of public funding for private school tuition in his paper "The Role of Government in Education" (Cunningham, 2016). Friedman has been considered a great supporter of school vouchers requesting the government to fund education and not operate schools (Wolf et al., 2013). As an economist, Friedman argued that providing vouchers to parents would create a competitive atmosphere among private schools that would lead to more educational efficiency in both educational private and public sectors. According to Peterson (2003), James Blaine proposed the Blaine Amendment to the federal Constitution in 1875. The provisions of the Blaine Amendment prevented aid to schools that have a religious affiliation. Thirty-eight states adopted the Blaine Amendment though the Amendment failed, and it is officially known as the "failed Amendment." According to Justice Stephen Breyer, the amendment weakens the risk of the democratic foundations in the US (Peterson, 2003). Peterson historically relates the Amendment to James Blaine who was a republican presidential candidate. Blaine "sought the anti-immigrant vote by campaigning to deny public funds to Catholic schools" (Peterson, 2003, p. 8).

2.2 Expansion of school voucher programs

School vouchers are one of three primary policies that states adopted to expand private school choices. “School vouchers are state-funded scholarships that pay for students to attend private school rather than public school” (Cunningham, 2016, para. 1). As of November 2016, NCSL stated that fourteen states plus the District of Columbia offered school-voucher traditional programs as a form of private school choice (Cunningham, 2016). Every state had different criteria of eligibility to students who would benefit from the voucher program enacted by the state. According to NCSL, the number of states offering private school vouchers has doubled between the years 2010 and 2017 (Cunningham, 2017). As of 2019, sixteen states and Washington, D. C., and Puerto Rico enacted twenty-nine voucher programs. In 2019, about 200,000 students used school vouchers to pay partial or full tuition at their private schools (EdChoice, 2019).

2.3 ***Milwaukee Parental Choice Program (MPCP); the Pioneer Voucher Program:*** In 1990, Wisconsin became the first state to apply modern school vouchers when legislators offered vouchers for students of low-income households in Milwaukee known as the Milwaukee Parental Choice Program (Cunningham, 2017; Eckes & Mead, 2016). At the beginning of its enactment, the MPCP was limited in terms of the percentage of students enrolled in participating private schools. The participating schools were not allowed to accept more than 49% of their total student population at approximately $2500 per student back then.

2.4 ***Florida; A Story of Successful Voucher Programs*****:** In 1999, Florida created the John McKay Scholarship for Students with Disabilities Program, the first special education voucher program nationwide. The McKay scholarship program is granted to students with disabilities who have Individualized Education Plan (IEP) or 504 plans all over the state. In 2001, Florida enacted a Tax-Credit Scholarship (TCS) program. “Florida’s tax-credit scholarships can be worth up to 96 percent of the state’s unweighted Full Time Equivalency (FTE) per-pupil funding although scholarships cannot exceed a private school’s tuition and fees” (Bedrick & Burke, 2018, p. 6). According to Bedrick and Burke (2018), 108,098 Florida students received a tax-credit scholarship to attend more than 1,800 participating private schools during the 2017-18 school year. In 2019, Florida expanded this program to be incorporated into the Family Empowerment Scholarship program to expand school choice options for low- and middle-income families (EdChoice, 2019).

2.5 ***Arizona; A Story of Perseverance*****:** Arizona created two voucher programs: Arizona Scholarship for Pupils with Disabilities and Arizona Displaced Pupils Choice Grant. The Arizona Supreme Court struck down both programs and ruled they were unconstitutional because the two traditional programs violate the aid clause that states, “no tax shall be laid or appropriation of public money made in aid of any church, or private or sectarian school, or any public service corporation” (Eckes & Mead, 2016, p. 722). In response to the Arizona Supreme Court, Arizona enacted a new voucher program called Empowerment Scholarship Account (ESA) which allowed students of disability to get 90% of the estimated cost of education in a public school to pay for private school tuition and other expenses. The appealing Court of Arizona supported the ESA in 2013 and rejected the allegations that the ESA violates the aid clause of the state.

2.6 ***The Race of Implementing Voucher Programs*****:** In 1999, Ohio enacted the Cleveland voucher program, which is remarkably like the MPCP in Milwaukee. Later, between 2003 and 2007, Ohio, Utah, Arizona, and Georgia enacted similar school-voucher programs to support students with disability and autism. In 2004, President George W Bush signed the District of Columbia School Choice Incentive Act to

be “the first federally funded school voucher program in the United States” (Wolf et al., 2013, p. 246). In 2007, Utah was a pioneer to propose the first statewide universal school vouchers which provided funds to every student in the state without restrictions and away from any measurements of eligibility. However, the program was not implemented because the voters revoked the program in the ballet of 2011. In the same year, 2011, Indiana initiated a state-wide voucher program for every low-income student. The program was launched in the school year 2011-12 and provided vouchers for students whose family income could be less than 150% of the federal poverty level. In 2013, the Indiana Supreme Court upheld the program concluding that the voucher program is not a replacement for the public-school system (Catt & Rhinesmith, 2017).

In 2008, Louisiana enacted and launched the Student Scholarships for Educational Excellence Program. This program, formerly known as the Louisiana Scholarship Program, covered private school tuition and fees. According to EdChoice (2019), the deductions were up to $5,000 per student. The Student Scholarship for Educational Excellence program supported low-income students who attended a low-performance public school in the previous year. In 2010, Louisiana enacted the School Choice Program for Certain Students with Exceptionalities. This voucher program included six categories of learning exceptionalities including students who have IEP and those who live in a parish with a population over 190,000. The average scholarship is $2,500 which represents only 20% of the average expenditure of a student in public schools in Louisiana (EdChoice, 2019).

In 2013, Alabama offered its Education Scholarship Program which is a tax-credit scholarship to support students qualified for reduced-price lunch programs who attend a failing public school (EdChoice, 2019). The scholarship covers the private school tuition up to $6,000 in grades k-5, $8000 in grades 5-8, and $10000 in grades 9-12. Recently, the trial court of Alabama struck down the Alabama accountability Act which refers to the tax-credit scholarship program in Alabama. However, the Alabama Supreme Court went against this ruling in a conditional case based on the low performance of certain public schools. In other words, the Supreme Court gave the parents of the student who attended a failing school to fund the tuition of a private school to which they may transfer.

In 2016, the state of Maryland enacted and launched its first school choice program called Broadening Options and Opportunities for Students Today (BOOST) (EdChoice, 2019). BOOST provided vouchers for students coming from low-income families to attend private schools. BOOST scholarship is almost 19% of the average expenditure per student in Maryland public schools. In 2019, 3200 students received BOOST vouchers to enroll in the participating schools.

In 2017, New Hampshire launched its Town Tuitioning Program which replicated the enacted program in Vermont in 1869. The program allowed students to use public dollars to enroll in public or private schools in or outside New Hampshire (EdChoice, 2019). Town Tuitioning program excluded religious schools from the student’s choice and would pay only for a public school or a private approved school. In 2018-19, nine participating students received help from the state Town Tuitioning Program to enroll in one participating school. In 2021, New Hampshire launched its voucher program known as Education Freedom Accounts (EFA). This program allowed parents to apply for educational grants to cover the expenses of private school tuition, tutoring, and other educational expenses with an average expense of $4,600 per child.

In 2018, Puerto Rico enacted its first voucher program known as Free School Selection Program (EdChoice, 2019). Puerto Rico launched the program in 2019 and determined the eligibility of students in grades 2-12 coming from low-income families who spent two consecutive years in public or charter school before transferring to a private or public school of their choice. Also, the program provided grants for gifted students to take courses at local universities. In 2020-2021, one percent (1%) of the total student population enrolled in the Free School Selection Program.

3. Voucher programs opposition

3.1 Voucher programs and segregation

It may be quite common to hear opponents of voucher programs reporting that vouchers would increase segregation. Whereas exponents of school choice reject this claim asserting the opposite. So, it is highly recommended to find empirical data that may prove or refute one of the claims or both. For instance, Egalite et al. (2017) conducted a study to examine the effect of the Louisiana Scholarship Program (LSP) on racial stratification. This study is particularly important regarding racial stratification since it was conducted in a state with a history of state-sponsored segregation. The study could document quantitative data by tracking LSP students who transferred from public to private schools. The overall findings of this study proved that LSP did not increase the racial segregation in public schools from where students moved. On contrary, transferring from public to private schools had a significant effect on reducing racial segregation in public schools. The results provided more details about a major factor that may increase or decrease racial segregation in public schools. Egalite et al. (2017) explained that transferring from public to private schools may increase racial segregation when the percentage of transferring students' race is lower than the students of that race in public school districts. “The overwhelming majority (82%) of LSP student transfers reduced racial stratification in sending schools. Conversely, less than a fifth of transfers increased racial stratification in the former public schools of LSP students" (Egalite et al., 2017, p. 284). At the same time, the study recorded that 45% of the LSP transfers slightly increased racial segregation in private schools to which students moved to.

3.2 Religious schools and fundamentalism

The advocates of excluding religious schools from public funds have concerns because of the increasing fundamentalism around the world. However, opposing financial support has not been proven to defeat intolerance. Peterson (2003) stated that there is no straightforward evidence that religious schools teach intolerance. On the contrary, the studies show that students who study in catholic schools show more tolerance than other students who studied in public schools. These students are more active and engaged in political and social life when compared with their peers in public schools. Peterson pointed out that Catholic schools strive to teach students democratic values because of the harsh criticism from society. Peterson expected that Jewish and Muslim schools would do the same in case students get vouchers to enroll in such religious schools. According to Peterson (2003), Justice Sandra O’Conner sees that preventing religious schools from accessing public funds does not make any sense because the taxpayer dollars go to these religious institutions in other ways such as Pell Grants, childcare programs in churches, synagogues, and direct aid to parochial schools.

According to Cheng et al. (2016), parents do not choose religious schools only because of their religious instruction, but because of other reasons such as high academic standards, affordability, discipline, moral values, and safety. Whereas some parents prefer religious schools because they are more affordable than private schools in terms of school tuition. The research results of Cheng et al. proved that the likelihood of selecting religious schools, in general, is twice the likelihood of choosing secular private or public schools. The study showed that when parents are interested in a strong disciplinary educational environment, they are six times more likely to choose catholic schools than public schools. This is the case in Washington DC where parents participating in the Signature Scholarship Program (SSP) sent their kids to catholic schools instead of protestant schools because they were interested in strong discipline and academic rigor (Trivitt & Wolf, 2011). “The SSP is a privately funded, partial tuition scholarship program designed to mirror the operation of a publicly funded voucher program and predates the publicly funded voucher initiative in DC called the Opportunity Scholarship Program” (Trivitt & Wolf, 2011, p. 204). In their

study, Trivitt and Wolf found that parents select the faith-based schools that align with the religion they practice as is the case with MPCP participants. In Milwaukee, the vast number of enrollments is in religious schools. Trivitt and Wolf reported that 44% of the MPCP voucher students enrolled in catholic schools while 19.1% of voucher students enrolled in Lutheran schools. So, what is the point of excluding faith-based schools from voucher programs if parents choose to send their children to religious schools?

4. Voucher programs from the perspective of empirical studies

Although the early empirical studies had provided mixed results of the voucher programs, recent studies have rich evidence of the positive impact on the test scores of the students who received help from voucher programs. Early studies did not show a significant difference between the scores of the school choice students versus their peers in public schools. Other early studies had no consistency in terms of the findings and results. Moreover, the results of the early studies contradicted. For example, Witte et al. (1995) conducted the first empirical study in Milwaukee to evaluate the MPCP after four years of its implementation. The study found that there was no significant disparity in achievement between the students enrolled in the MPCP and their peers in public schools. However, the study of Witte et al. received a lot of criticism, especially for using a comparison group that represented students of substantial advantaged families compared to the group of the MPCP (Rouse, 1998). According to Rouse (1998) Greene, Peterson, Du, Boeger, and Frazier conducted a study in 1996 that replaced the comparison group with a quasi-experimental control group that consisted of a group of unsuccessful applicants from public schools. The new study of Greene et al. revealed a significant difference in test scores in favor of the MPCP students in their third and fourth years in reading and math. Rouse (1998) replicated the study of Greene et al. by selecting non-successful applicants and a random sample of students who attended Milwaukee public school as a comparison group. The study showed that the students of MPCP scored 1.5 to 2.3 percentile per year more than the students at public schools in Milwaukee.

New research gives a boost to proponents of school choice and states positive results for implementing vouchers and voucher-like programs. For example, Peterson and his colleagues' research showed that African American students' scores on standardized tests were substantially higher than the scores of African American students who stayed in public schools in New York City, Washington D.C., and Dayton (Peterson, 2003). After three years of enrollment in voucher schools, the scores of African American students were eight percentage points higher than the comparable students who remained in public schools. It is important to mention that the study sample included African American students enrolled in both religious and non-religious private schools. Also, students who moved from public to private schools scored higher (Barrow & Rouse, 2008; MacLeod & Urquiola, 2012).

Recent studies have also supported Friedman's theory about raising competitiveness and productivity in education because of applying voucher programs. For example, when Florida implemented its voucher program in 1999, it was a threat to certain public schools which did not achieve the minimum requirement of test scores because more of their students would be eligible to get vouchers (Greene, 2001; Greene & Winters, 2003; Figlio & Rouse, 2006; West & Peterson, 2006). The findings of these researchers proved that the test scores of students at the threatened schools improved significantly compared to the test scores of the other schools. According to West and Peterson (2006), such failing schools were pressured to enhance the educational services they offered to retain their students. This research of West and Peterson is especially important to reflect on the impact voucher programs may have on the efficiency gains of public schools. Not only do students switching from public to private sector benefit from the

voucher programs, but also students who go to public schools can improve because of the enhanced educational services offered in a competitive educational market.

5. Parents' preference for private schools

The results of new polls showed a shift in public opinion that supports the expansion of school choice (Wong, 2018). According to Cheng et al. (2019), results from the 2018 *EdNext* Poll showed that 44% of 4601 respondents were in favor of a proposal called universal-choice policies with voucher labels that can be applied toward children's tuition to enroll in private schools. This poll surveyed a nationwide sample of adults that represented parents, teachers, black, white, Hispanic, Republicans and Democrats. Beacon Center of Tennessee and Friedman Foundation for Educational Choice (2012) conducted a survey that showed 60% of the Tennessee voters were in favor of the school voucher programs (New Poll Shows Tennessee Voters Favor Private School Vouchers, 2012). The percentage of voucher supporters was the same as the percentage of charter schools' approval, which recorded 61%. According to the survey results, urban voters, Republicans, and African Americans were among the highest supporters of private school vouchers. The survey also recorded that choice, flexibility, and freedom were the most frequent answers of the voters to explain why they support vouchers. Such answers reflect the parents' desire to be more involved in choosing the schools that best fit their kids.

High test scores of private school students may justify parents' preference for private schools over public schools. In 2006, the NAEP report showed that the average scores for reading and mathematics of students in private schools in grades 4 and 8 were significantly higher than the scores of their peers in public schools (Braun et al., 2006). The research conducted by Wolf et al., (2013) supported the positive impact of the Washington DC voucher program on the high school graduation rate. Wolf 's study has also shown that the reading achievement of the students enrolled in private schools has increased. The study by Rouse (1998) revealed that the math scores of students in the Milwaukee Parental Choice Program (MPCP) improved faster than the comparison group of students in Milwaukee public schools.

6. Analytical discussion

With all opposition to the school voucher program proposed for private schools, the data available from the literature review proves that there is a growing interest in school vouchers as a means of funding private schools' tuition. In addition, the number of states that support and implement voucher and voucher-like programs is growing. Cunningham (2017) stated that there are twenty-seven states plus the District of Columbia that support private school choice using public funding such as traditional school voucher programs, scholarship tax-credit, or education savings accounts. As of January 2017, fifteen states, out of the twenty-seven, offer traditional voucher programs. According to Wolf et al. (2103), "*The Wall Street Journal* declared 2011 "The Year of School Choice," as 41 state legislatures either passed or at least held hearings on school voucher or tax-credit scholarship bills" (p. 267). The number of private schools participating in MPCP increased from seven private schools in 1990 to 128 private schools in 2018. The expansion of voucher and voucher-like programs during the last two decades reflects a significant shift in parents' perspectives of the efficacy of education in private schools. At the same time, the literature review could not provide inclusive evidence of the ineffectiveness of the vouchers paid to private schools in the form of full or partial tuition. A quick analysis of the voucher models implemented in Milwaukee and Washington DC indicates that minority parents are incredibly supportive of voucher programs. In Florida, a recent survey, which was conducted to measure the satisfaction of TCS parents, showed that 92% of parents were satisfied including 89% who were completely satisfied (Bedrick & Burke, 2018). While parents who were completely dissatisfied did not exceed seven percent (7%).

There is a common trend to discuss and evaluate voucher programs' effectiveness based on test scores and student achievement. However, this trend neglects the reasons for parents to enroll their children in private schools. Data shows that parents enroll their children in private schools for several reasons such as safety, strong discipline, special curricula including religious instruction, and cultural aspects that are missed in public schools. For example, Bedrick and Lindsey (2018) surveyed Florida scholarship families to identify the top three factors to choose certain schools, the results indicated that 66% of parents valued religious instructions, 52% were in favor of discipline, 36% were interested in a safe environment, 34% choose schools of good academic reputation, and 31% were looking for schools with small classes. The survey has also documented that the least likely factor was the high standardized test scores which reached only four percent of the surveyed parents. Standardized tests were initially implemented to measure the accountability of public schools; however, this criterion finds great opposition in public schools themselves. "The standardized tests that have been the backbone of school accountability systems are losing popularity and public trust" (DiPerna & McShane, 2018, p. 1).

There is growing evidence that students enrolled in school choice programs are more likely to graduate high school (Cunningham, 2017). It is rarely mentioned that students who receive vouchers and go to private schools displayed significantly higher graduation rates than their peers in public schools. They are also more likely to enroll in college and get a college degree. Recent studies have been conducted to investigate the effect of FTC scholarship program (Chingos & Kuehn, 2017), the DC OSP (Wolf et al. 2010), and MPCP (Wolf et al., 2013) on high school graduation rate and college enrollment. The three programs are publicly funded private-school choice programs in Florida, Washington DC and Milwaukee respectively. The findings of the three studies showed a positive effect of the school choice programs on both graduation rate and college enrollment. "For example, Wolf and coauthors' (2010) study of the Washington, DC, school voucher program found stronger evidence of effects on high school graduation rates than on test scores, with the offer of a voucher increasing graduation rates 12 percentage points" (Chingos & Kuehn, 2017, p. 1). In addition, the study of Chingos and Kuehn showed that the longer the time students experienced FTC voucher programs the more likely they are to enroll in Florida public colleges in both two-year and four-year colleges. It is time to consider the higher graduation rates of private schools as a good sign of the rigor of private schools, their effectiveness, and accountability. We cannot drop out the higher graduation rates from our calculations when we judge private schools and the vouchers that fund students at private schools.

Recent studies have also indicated positive effects of parents' engagement when their children switch to private schools. According to Bedrick and Burke (2018), TCS parents in Florida became more involved in their children's education and more engaged after switching from public or charter schools to private schools. For example, Florida scholarship parents had a significant positive effect on communicating with teachers, participating in school activities, volunteering, helping their kids with homework, and using online educational resources after their kids switched to private schools.

Opponents of school voucher programs have been arguing that funding private and religious schools is unconstitutional. However, the history of the cases that concluded "funding private and religious schools is constitutional" was more than the cases that judged "it is not constitutional." According to Mead 2015, vouchers and voucher-like programs were upheld in eight states where the trial, appellant, or supreme courts proved the constitutionality of the programs. Whereas the opponents of voucher programs won only five cases. Over the last two decades, school choice programs have expanded to cover various forms such as charter schools, conventional vouchers, magnet schools, neo-vouchers, open enrollment, and pathways (Mathis, 2013). However, private schools are still disadvantaged by this public fund except for limited tax benefits and partial enrollment. It is not fair that parents who pay property taxes, which is a major source of public-school funding, gain no benefit toward their kids' education when they choose to send their kids to private schools.

7. Conclusion

This paper is not intended, by any means, to diminish or demolish the role of public schools in educating children. Neither does the article propose any kind of superiority of the private sector over the public school system. The paper is a humble contribution to bringing equity and inclusiveness to the greater educational system by adding private schools, both secular and religious, to the school choice programs as a right of parents to choose the type of education that may better fit their children. So, the article focuses on the positive results of the recent empirical studies as well as the shift of parents' opinions on private and public schools to urge legislators to review the policies that have been preventing voucher programs from being listed among the pool of school choice presented to parents and students. The article also recommends voucher programs for private schools as a means of achieving social justice by giving an equal opportunity to low-income students to join private schools as well as their peers from wealthy families. Moreover, the article tries to aluminate the available literature that showed the positive effects on public schools and promoted a market-like competition between public and private schools. This means supporting private schools through vouchers can be an indirect way of supporting public schools that would join the race toward efficacy, accountability, higher performance, and better achievement. The article presents the successful voucher programs implemented in Florida, Milwaukee, and Washington DC to say these programs can be echoed. Hence, the paper suggests the implementation of similar voucher programs experienced in Florida, Milwaukee, Washington DC, and Indiana. The main goal of expanding the vouchers to more states is to best serve the educational needs of students and better satisfy the parents' desire to choose the type of education they like their children to have. Educational equity cannot be solely offered to students attending public schools. Otherwise, insisting on excluding private schools from vouchers or voucher-like programs makes equity lack the true meaning of inclusiveness.

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Commercial Airline Passengers' Willingness to Fly with COVID-19 Safety Measures

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Abstract

In the commercial aviation industry, safety is always a primary concern, with a central focus on the well-being of passengers and crew members. Given the significance of safety, the COVID-19 pandemic has resulted in drastic changes to the way commercial airlines operate. The airline industry has had to adopt precautions to help ensure safety by minimizing the risk of transmission for both passengers and airline employees during air travel.

We examined passengers' willingness to fly with various commercial airline COVID-19 safety precaution scenarios: control (none), face coverings (masks), negative PCR test, boarding and deplaning five rows at a time, and paired combinations of these precautions. The within-subject design assessed Willingness to Fly (Rice et al., 2015, 2020) for all scenarios in random order. Participants were recruited from the US Amazon Mechanical Turk (MTurk) user population. Willingness to fly was positive for all scenarios (N= 202). The control scenario, with no precautions listed, had the lowest willingness to fly (0.69); Scenario 3, negative PCR test required, had the highest willingness to fly (0.81). However, contrary to expectations, there was no statistically significant difference in willingness to fly between the scenarios. These results suggest that participants are willing to fly regardless of the precautions, meaning that air travelers are still willing to fly under the commonly used pandemic precautions or without.

Keywords: Willingness to fly, airline passenger, COVID-19 pandemic, masks, unruly passengers

1. Introduction

The COVID-19 pandemic has had a global impact on numerous industries, with the commercial airline industry critically affected. As the pandemic continues, commercial airlines have had to adjust to constantly developing information on the COVID-19 virus itself, as well as changing regulations on travel from both countries and airlines. Research examining the perception of the commercial airline customer during the pandemic is crucial to understanding how the industry can adapt. Commercial airlines need to understand the perceptions their passengers have towards the safety precautions that are being implemented. This study provided information into the changing perception commercial airline passengers have towards the constantly changing government mandates and airline safety precautions. Findings from this study could potentially help airlines save money and resources in times of extreme

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circumstances.

The purpose of this study was to examine whether various commercial airline COVID-19 safety measures influence passengers' willingness to fly. The willingness to fly scale (Rice et al., 2015, 2020) measured consumer willingness to fly. Participants from Amazon Mechanical Turk (MTurk) rated their willingness to fly on a 6-hour commercial flight under current COVID-19 safety scenarios: control (no precautions), face-covering (mask) required, negative COVID-19 polymerase chain reaction (PCR) test, boarding and deplaning five rows at a time, and the three paired combinations of these safety measures.

2. Literature Review

Aviation has been impacted globally by the COVID-19 pandemic. From initial lockdowns to mandated precautions, the commercial airline industry has continued to operate, while also working to maintain safety and promote air travel. As commercial air travel increases back to pre-pandemic levels, the details on safety and transmission while traveling on commercial airlines have been extensively investigated. According to Khatib et al. (2020), air quality in modern commercial aircraft is very safe. Approximately every three to four minutes during flight, cabin air is recirculated and mixed with fresh air, free of microorganisms. Before flowing back into the cabin, recirculated air passes through HEPA (High-Efficiency Particulate Air) filters. These filters are highly effective in removing airborne particles, with 100% effectiveness in removing large airborne particles (Khatib et al., 2020). Major airline manufacturers around the world have all conducted several tests that involve the different mechanics of their air filtrations systems, and their effectiveness in filtering hazardous particles. European-based Airbus, U.S.-based Boeing, and Embraer in Brazil have all conducted independent studies utilizing computational fluid dynamics models. Each manufacturer concluded that aircraft air systems limit the spread of airborne pathogens by controlling the flow of air and particles within the cabin (Khatib et al., 2020).

Since March of 2020, the most widely mandated and recommended safety measure has been the utilization of face coverings in indoor or public settings. The wide implementation of this measure has been accompanied by skepticism and criticism, despite its effectiveness. Wang et al. (2020) conducted observational research showing face-covering effectiveness in reducing SARS-CoV-2 virus transmission in Beijing households. When all members of the household used a mask before the onset of COVID-19 virus symptoms, face coverings were 79% effective in reducing transmission. Leffler et al. (2020) found that in countries without any mask mandates the COVID transmission rate was 7.5 times higher than in countries with a mandate. Lyu and Wehby (2020) suggested that in the early period of the pandemic, US states that delayed imposing mask mandates saw a daily increase in COVID-19 cases that was 2.0 times higher than states with masking. Mandates prevented somewhere between 230,000 to 450,000 cases by May 22, 2020 (Lyu & Wehby, 2020). The use of masks and implementation of mask mandates are effective tools in preventing the transmission of the COVID-19 virus.

Masks and face coverings have been a strict requirement implemented by every US airline since the beginning of the pandemic. In addition to mask-wearing, several countries around the world have implemented strict guidelines stating that all international travelers must present a polymerase chain reaction (PCR) test with a negative result, before entering the country. For example, every international

traveler is required to show a negative test to be able to enter any European Union country, per their latest regulation (European Centre for Disease Prevention and Control [ECDC], 2021). Following the initial stages of the COVID-19 pandemic, the International Air Transportation Association (IATA) suggested testing could be a viable alternative to 14-day self-quarantine, and highly recommended the alternative for international travelers (Khatib et al., 2020).

Another commonly implemented safety measure was social distancing. Following the start of the pandemic, virtually every establishment had some form of social distancing procedure in place. Mahtani et al. (2020) examined different recommendations from the CDC and WHO and found that isolating ill individuals and six-feet separation (i.e., distancing) both have a substantial impact on minimizing transmission. In the absence of pharmaceutical prevention, the physical separation of individuals is one of the most effective practices in reducing the transmission of a respiratory virus (Mahtani et al., 2020).

Airlines have also implemented boarding and deplaning strategies, which is the main way to increase distancing during these processes. During air travel, the risk of contracting a virus is typically highest during the boarding and disembarking periods. Thus, airlines have limited the total number of passengers who can board and deplane at the same time (Schultz & Soolaki, 2020). Airlines have adopted the strategy of embarking and disembarking passengers by a certain number of aisles at a time. Airlines will typically board five to ten aisles at a time, which has increased both boarding and gate time.

However, in addition to effectiveness, the social response to the implementation of safety measures is critical. While the majority of individuals accepted new safety protocols, many countries noticed factions of resistance within their communities. Forsyth (2020) described the increasing popularity of resistance towards health recommendations, as health mandates progressed past simple mask-wearing. Self-quarantining and the rise of possible vaccine mandates helped solidify the divide between groups of individuals that supported and resented COVID-19 safety measures. Forsyth (2020) found that many groups believed that safety measures were ultimately ineffective and no longer necessary.

In aviation, mandated safety precautions also resulted in strong resistance from many passengers, in the form of unruly behavior. A recent exponential increase in unruly passenger activities aboard commercial airlines has been seen in the last year. According to the Federal Aviation Administration, flight crews have reported 128 new unruly passenger incidents, in one week alone; this brings the 2021 total to 4,626 incidents. In addition to this, it was reported that 72 percent of these incidents were related to the mandatory use of face coverings (FAA, 2021).

The COVID-19 pandemic has not only proven to be a public health crisis, but also an economic and social calamity. The virus has impacted many industries; however, it has had a particularly greater impact on the transportation and travel industries, such as the commercial aviation industry. In the global effort to contain the spread of the COVID-19 virus, governments around the world imposed partial or complete closures of their international borders, for nonessential and noncitizen travelers. In addition to the closure of their borders, they imposed strict travel restrictions and issued travel notifications advisory to reduce unnecessary travel. These measures have led to an unprecedented drop in the demand for air travel; as a result, the aviation sector has become one of the most heavily affected by COVID-19 (ICAO, 2020).

In May 2021, the Bureau of Transportation Statistics [BTS] (2021) showed that the US airlines responsible for 90 percent of passengers carried, saw an increase of 607 percent in scheduled passenger traffic, from a year earlier. While this is a positive trend, airlines are still carrying 30 percent fewer total passengers compared to the pre-pandemic period of May 2019. The BTS continues by stating that international air travel saw an increase of 2522 percent from May of 2020 to 2021, with domestic air travel increasing by 561 percent. These findings show that, while still in a recovery phase, the US and global air travel are returning to pre-pandemic levels.

While many factors contribute to the continued low rate of air travel, one potentially key factor is passengers' willingness to fly. Lamb et al. (2020) described how many passengers may question the safety of air travel has, in the mindset of a respiratory virus pandemic, because air travel confines passengers to a small space for varying lengths of time. Individual willingness to travel by air in the US is impacted by trust issues, emotional heuristics, and precautionary frameworks. Lamb et al. (2020) stated that female passengers had substantially higher trust issues with airlines and airports; men had higher trust issues with information and people. In addition, women had a substantially higher level of fear of others and a need for self-care, while men had a higher level of anger, frustration, and anxiety. These findings suggest that commercial airlines' willingness to fly during a pandemic is likely a dynamic construct, subject to a wide array of factors.

Sotomayor-Castillo et al. (2021) said that contracting COVID-19 and doubts over the safety of the airline measures were concerns for a majority of routine air travelers. Similarly, Lamb et al. (2020) revealed that a majority of frequent air travelers changed their travel patterns because of perceived threats and fear of COVID-19. These studies revealed that passengers prioritize their health over travel commitments, while others resort to online interactions and transactions to minimize air travel (Lamb et al., 2020; Sotomayor-Castillo et al., 2021). Similarly, Wheeler et al. (2021) found that student pilots were significantly less willing to fly in a control scenario than in scenarios with various COVID-19 precautions. This pattern of caution was true even when there was only one other person in the aircraft.

The COVID-19 pandemic has introduced logistical and operational challenges for commercial and transportation industries, particularly aviation. Factors such as the safety of traveling on an aircraft during a pandemic and the specific safety precautions mandated may influence passenger willingness to fly. The increase in unruly passenger activity, the decrease in passenger traffic, and the financial impact on the aviation industry all point to the need for a better understanding of passenger willingness to fly both during the COVID-19 pandemic and to inform transportation safety precautions in future pandemics.

3. Methods

During the last week of October 2021, participants were recruited from users of Amazon Mechanical Turk (MTurk), who were in the United States. The IRB exemption (21-106) was approved. All participants were compensated equally, and data was collected anonymously. All participants were at least 18 years of age and gave consent before beginning the study.

Participants were asked about their willingness to fly (Rice et al., 2015, 2020) on a 6-hour commercial airline for each of seven different COVID-19 safety scenarios. The willingness to fly scale

developed by Rice et al. (2015, 2020) has been tested for validity and reliability in the Mturk population. The seven COVID-19 safety scenarios were selected as actual airline practices during the pandemic: 1) the US airline lists no COVID-19 restrictions at this time, 2) the US airline lists that face coverings are required during the entire duration of the flight, 3) the US airline lists that a negative PCR test is required, within 72 hours prior to departure, 4) the US airline lists that passengers' will be embarked/disembarked 5 aisles at a time, 5) the US airline lists that face coverings are required during the entire duration of the flight, AND a negative PCR test is required, 72 hours prior to departure, 6) the US airline lists that a negative PCR test is required, 72 hours prior to departure, AND that passengers' will be embarked/disembarked 5 aisles at a time, and 7) the US airline lists that face coverings are required during the entire duration of the flight AND that passengers' will be embarked/disembarked 5 aisles at a time.

This study was a within-subject design; each participant was presented with all seven scenarios. Data was collected using a Qualtrics questionnaire distributed to adult MTurk users in the US. Responses were converted from the Likert scale to numerical values: strongly disagree -2, disagree -1, neutral 0, agree 1, strongly agree 2. Cronbach's alpha was calculated as a measure of internal reliability. Descriptive statistics were calculated in Microsoft Excel. Cronbach's alpha and an ANOVA were calculated in R Studio.

4. Results

The United States-based participants from Amazon Mechanical Turk (MTurk) were recruited with a total of 202 participants completing the survey, and ages ranging from 18 to over 65. Table 1 displays the age distribution of responses. The age group with the highest number of participants was the 26 to 35 years old (91); the age group with the lowest number of participants was 66 years and above (3). The majority of participants (72 percent) were 26 to 45.

Table 1. Age Distribution of Participants

Age Group	Number of Participants	Percentage
18-25	26	13%
26-35	91	45%
36-45	55	27%
46-55	20	10%
56-65	7	3%
66+	3	1%

Participants reported their commercial travel habits, including how many times they typically fly on a commercial airline in a normal year (pre-COVID-19 pandemic) and how many times they have flown on a commercial airline since January 2020 (see Table 2). Slightly less than half of the participants (90) responded that they typically fly three to four times in a normal year. Five participants responded that they typically fly zero times in a normal year.

Table 2. Number of Times Participants Have Flown

Times Flown	In a Normal Year	Since January 2020
0	5	22
1-2	69	95
3-4	90	66
5-10	32	19
11+	6	0
Total	202	202

Table 3 demonstrates that there was a high level of internal consistency among the responses for all scenarios, and therefore, all future statistics were conducted on participants' average willingness to fly score for each scenario (i.e., mean of the seven items on the scale for each scenario).

Table 3. Cronbach's Alpha for Willingness to Fly

Scenarios	Precaution	Cronbach's Alpha
Scenario 1	No Precaution	0.91
Scenario 2	Mask Required	0.86
Scenario 3	PCR Test Required	0.86
Scenario 4	Five Aisles at a Time	0.88
Scenario 5	Masks/PCR Test	0.88
Scenario 6	PCR Test/Five Aisles	0.87
Scenario 7	Masks/Five Aisles	0.87

Table 4 and Figure 1 show the descriptive statistics for the average willingness to fly in each scenario. The average for each scenario was consistently close to one; this indicates that responses were close to "Agree". The first scenario (control) had the lowest mean, demonstrating that participants on average felt slightly less willing to fly with no COVID-19 safety precautions. The third scenario had the highest average, which means that on average participants felt slightly more willing to fly when a negative PCR test was required 72-hours prior to departure.

Table 4. Descriptive Statistics for Willingness to Fly with Various COVID-19 Safety Precautions

Statistic	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Mean	0.69	0.79	0.81	0.73	0.76	0.77	0.76
Median	1	1	1	1	1	0.86	0.86
Mode	1	1	1	1	1	1	1
Max	2	2	2	2	2	2	2
Min	-2	-2	-2	-2	-2	-2	-2
Range	4	4	4	4	4	4	4
St. Dev.	0.91	0.73	0.74	0.78	0.8	0.77	0.77

The repeated measures ANOVA found no significant difference in willingness to fly between the scenarios: F (1,411) = 0.19, p= .66. The eta squared ($\eta 2$ = 0.00014) indicates an extremely small effect size.

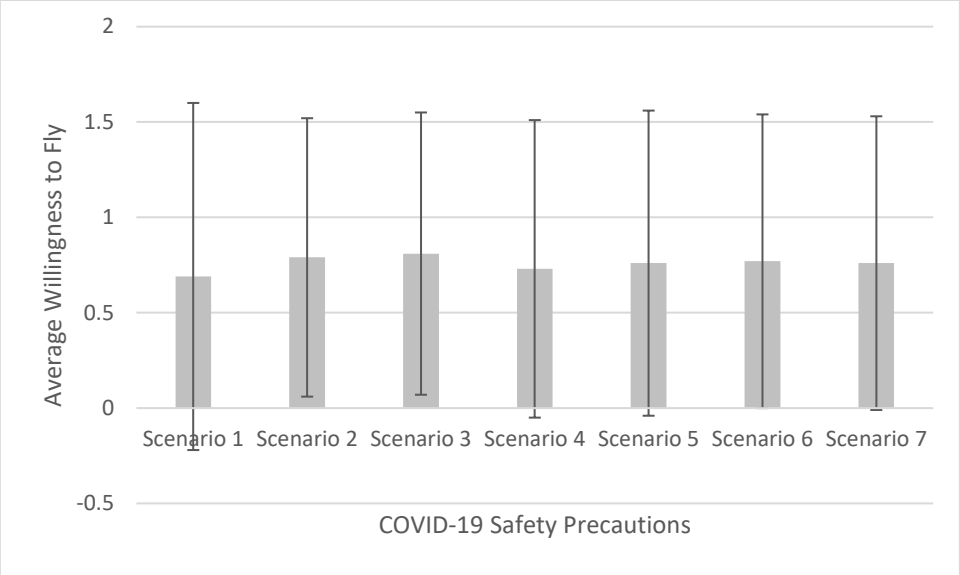

Figure 1. Participants' Willingness to Fly with COVID-19 Safety Precautions

Note: Scenario 1 (no precaution), Scenario 2 (masks required), Scenario 3 (PCR test), Scenario 4(five aisles), Scenario 5 (mask and PCR test), Scenario 6 (PCR test and five aisles), Scenario 7 (masks required and five aisles).

5. Discussion

The objective of this study was to determine whether passenger willingness to fly differed from COVID-19 safety precautions on commercial flights. Contrary to expectations, there was no difference in willingness to fly between the scenarios (F (1,1411) = 0.19, p = .66, η2 = 0.00014). Across all scenarios from the control (no precautions) to the scenarios with two precautions, the participants had an average willingness to fly that was close to one (Agree). Thus, participants' willingness to fly was positive in all seven scenarios, and approximately the same across the different precautions. In a real-world application, there was no difference in the passengers' willingness to fly with or without various precautions, which although a non-significant finding, is an extremely positive outcome for the aviation industry because, at the time of the study, participants were willing to fly, regardless of precautions.

Approximately one year prior to this study, Part 141 student pilots were significantly less willing to pilot in a control scenario with no precautions (Wheeler et al., 2021). The current study was conducted in a different population, the general public, and for a commercial airline flight rather than a flight lesson with only a CFI present, this shows a shift in patterns of willingness to fly. Earlier in the pandemic, the control scenario had a negative willingness to fly (-.31) as compared to all other scenarios with various precautions (Wheeler et al., 2021). This shift is likely due in part to the availability of vaccines at the time of the current study and the length of the pandemic.

The results from this study are important for understanding consumer perceptions of the precautions implemented on commercial airline flights during the COVID-19 pandemic. Commercial airline passengers are confined to a small and compact area for varying lengths of time. Given the characteristics of COVID-19 and other respiratory viruses, there is a need for precautions while in confined spaces to maintain a level of safety. Although there was no statistically significant difference, the responses to the first scenario (control, no precautions) were the lowest (0.69); this shows that on average respondents

were slightly less willing to fly when there are no safety precautions present. Scenario 2 (masks required) and scenario 3 (PCR test required) both had the highest scores, 0.79 and 0.81, respectively. These precautions are two of the most commonly used by airlines, and they are safety measures that have been effectively used to minimize COVID-19 transmission. Interestingly, having two precautions in place did not yield higher willingness to fly scores.

All precautions were selected because they have been regularly implemented on US airlines during the pandemic. Obtaining a negative PCR test imposes both a cost and a challenge of finding available testing but may also provide confidence in knowing that passengers were not positive at the point of testing. The effectiveness of face coverings has been demonstrated; however, the American public was exhibiting signs of pandemic fatigue and pushing back against most COVID-19 safety measures at the point of this study. In terms of the commercial aviation industry, these results suggest that the majority of passengers would cooperate with additional safety measures; however, even without any precautions, they were still willing to fly. In addition, these results indicate that passengers are not only willing to fly with the safety measure but may also prefer them slightly.

Table 2 showed that the sample does represent the American flying public as the participants were regular air travelers, although the frequency of travel was lower since the start of the pandemic. However, most participants (172) were under the age of 46, while the age group with the highest risk of severe infection from COVID-19, 66 and over, only had three participants. This was a potential limitation to our study, as the sample, and potentially the accessible population was not completely representative of the American flying public, which has a larger percentage of travelers over age 65. If this study was replicated with a sample including more participants age 66 and over, the results may differ. However, the sample may accurately represent the subset of the population traveling at this point in the pandemic. Participants responded in general support of COVID-19 safety measures: 87 answered “strongly agree” and 89 answered “agree”. This may be due in part to the convenience sampling, and a population that did not agree with safety measures may yield different results. Participants were mostly either fully or partially vaccinated (179), with only 23 responding that they had not been vaccinated. It is possible that vaccination status, frequency of travel, and general attitude towards the COVID-19 pandemic also contribute to the willingness to fly. Further research should be conducted to examine vaccination status, history of COVID-19, and current willingness to fly.

US participants were approximately equally willing to fly both with and without COVID-19 precautions, a positive indicator for air travel. This study shows the willingness to fly at a specific time during the pandemic: October 2021. As a result, passengers’ willingness to fly will likely change with infection rates and developments in treatment. The findings from our research have practical implications for the commercial aviation industry that point to a brighter future as passengers are now willing to travel both with and without precautions. The general preference and attitude of commercial passengers’ is important information for airlines, both as the COVID-19 pandemic continues, and this study should be replicated in other extreme circumstances in the future.

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Incorporating Theory into Practice: A Historical Assessment of Layout Design and Bürolandschaft with Practical Applications to Modern Office Landscapes Using Performance Metrics

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Abstract

The historical upbringing of the theoretical foundations of layout planning and optimization provided several core principles from which other theories have been derived. Naturally, the development and transformation of layouts following modern tastes have unlocked new types of capabilities, but these benefits are not exempt from drawbacks. This study critically examines layout characterization and performance from both the historical and practical application perspectives. In fulfilling this objective, this study conducts an assessment of the existing body of foundational work in the domain of layout planning and Bürolandschaft, a German term that characterizes the conceptual nature of an office landscape, to capture the underlying motivations, insights, and benefits that are offered by this foundation. These theories are examined under the lens of a common focal point for many modern-day corporations: obtaining an ideal office layout. The historical findings imply that the manifestation of Bürolandschaft is closely related to the concept of an open office layout. Given these insights, an application of an open office layout to a modern-day organization is proposed. Furthermore, the resulting layout is assessed based on a variety of qualitative and quantitative layout performance metrics to observe the impact emerging from the application of theory to practice. More broadly speaking, the theoretical outcomes as suggested by historical developments are assessed in comparison to the outcomes resulting from a practical application.

Keywords: Layout Design, Lean Systems, Performance Metrics.

1. Introduction

In accordance with modern tastes and fluctuations in industry practices, the fundamental structure of layout design has shifted. Furthermore, the dynamics of the relations between management and labor have influenced and impacted layout design practices. The historical tendencies of layout practices cast light upon the culture and mindset of the time. These considerations are particularly significant when the social backlash emerging from such practices results in widespread shifts in preferences or laws.

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Throughout human history, there has been an observable cyclic pattern that is catalyzed by the natural introduction of change. Changes in processes, technology, practices, and the development of innovative concepts lead to impacts on people based on work/life practices and the overall standard of living. In turn, these types of influences on people change the prevailing societal mindset surrounding laws, policies, procedures, and philosophical perceptions of right and wrong. Likewise, these alterations to the rules of society fundamentally establish the parameters and constraints by which the next wave of innovation and change must occur.

As such, the study of history is critical to our modern understanding of life, especially regarding layout design. Examination of historical phenomena is regarded as important for two primary reasons (W. Hopp and M. Spearman, 2008). First, analogous to the workings of the Central Limit Theorem, the test of time (or through extensive repetition) offers a wealth of insight into the merits of a particular practice or concept. Second, the world is continually submerged in a state of change that demands fluid adaptation.

Leveraging these phenomena as an underlying motivation, this study seeks to examine layout design in relation to its most prevalent form for modern organizations: office design. First, an inspection of historical practices will be considered in order to capture the insights emerging from various time periods. Next, the open office and general open concepts will be characterized and the outcomes from such a design will be hypothesized. After this, literature will be surveyed in order to grasp the documented outcomes of open office studies to enhance the overall characterization of the design. Finally, an application is introduced in order to apply these findings to a modern context. The outcomes are compared from the basis of qualitative and quantitative performance metrics.

2. Historical background

Much like the prominent disciplines of management and engineering, layout planning has existed in various forms since the dawn of organized societies. However, the formal context that supports layout planning activities did not exist until the beginning of the first industrial revolution when people began to migrate from rural farmlands into urban cities to work in the up-and-coming industrial factories. While the dynamic factors that catalyzed these dramatic shifts are fundamentally complex, a significant amount of acknowledgment (A. S. Skinner, 1996) is paid toward Adam Smith's work titled An Inquiry into the Nature and Causes of the Wealth of Nations, informally known as The Wealth of Nations.

While the concepts that Adam Smith introduced are trivial to the modern individual, innovative ideas such as the division of labor had a profound impact on the nature of layouts in the industrialized society of the 18th century. During this time, facilities were primarily managed by owners who held little concern for human factors or the standard of living for employees. Factory workers were perceived through the lens of productivity rates, utilization, and cost in the same manner as machines. Layout planning was a secondary consideration. While the layout selection was far from strategic, resources were usually arranged to accommodate the division of labor concept which was pioneered by Adam Smith.

Another highlight in the history of layout planning emerged alongside the innovative work of Henry Ford (Curcio, V., 2013). Henry Ford drew inspiration from a variety of sources (Sloan, A. P., and Ford H., 2020) and he understood the value of observing the successful practices of other organizations. He

admired the works of Adam Smith and even wrote a chapter in his book titled The Wealth of Nations (Ford, H., 2002). Motivated by his appreciation for speed and high throughput, Henry Ford visited Otto Doering's spectacular mail-order system at Sears and Roebuck (Ulin, R. P., 1954) to observe how organizational resources and systems at large may be designed to enable high levels of speed and efficiency. When Ford applied these concepts to the production of the Model T, he realized the significant benefits associated with obtaining operational excellence even though American culture did not glamorize operations. The cost of a Model T was reduced by 58% from 1908 to 1916. Ford's infamous assembly line was organized as an in-line layout where the equipment dedicated to the production of the Model T was arranged in a roughly straight line. While this layout held numerous merits that played strongly to Ford's benefit, it lacked the flexibility to accommodate product variety (Groover, M. P., 2016). Even though Ford was bound by this limitation, he did not naturally seek to incorporate product variety unless he perceived it to be necessary.

3. Open office characterization

This leads to the primary focal point of this study: the open office layout. Fascinatingly, the open office layout is considered to be one of the first layouts that were widely recognized and accepted for office arrangements. One instrumental historical moment for the open office was the Bürolandschaft (also known as the Office Landscape Movement) which took place in Germany in the 1950s (Paletta, A., 2019). This movement holds connections to Taylorism, which was pioneered by Frederick Winslow Taylor in his book Principles of Scientific Management. The key motivation was for office spaces to place a central focus in the strategic design process on the flow of information in the workplace. In turn, companies adapted, and these changes still hold influence on office layouts to this day. From a historical perspective, there are a total of three key aspects that characterize a typical open office layout.

First, the open office directly targets efficiency through obtaining a high utilization of the space. This layout seeks to cluster personal spaces together in rows of desks, each assigned to one person, to enhance the ratio of communal space to personal space. Instead of having an entire room for an office, each person has one small area that may be mildly regarded as personal. An open office philosophy would perceive a traditional office room as having a high level of under-utilized space. In the traditional manifestation of an open office layout, the workers do not have much spacing separating them. In general, open office layouts are often motivated by a Taylorism mindset.

Second, there is high universality for the workspace. All spaces are communal to varying capacities and this impacts the work culture. The emergent outcome of this structure is threefold. First, team formation becomes more organic due to the natural grouping and clustering of labor, thereby increasing interpersonal interfacing. Second, the workplace remains in an optically ordered fashion since the natural clutter of personal spaces is minimized. Third, the expected utilization and efficiency of the function of the workspace increase when not all employees are present simultaneously.

Third, the open office layout places a strong focus on communal spaces. As widely noted in the literature, a phenomenon known as The Tragedy of the Commons often arises in communal spaces such as those proposed in an open office plan (Altman, A., 2012). In summary, when individuals perceive the maintenance of space as having communal responsibility rather than personal responsibility, the

conditions associated with the communal aspects of the space tend to erode over time unless someone is appointed to take responsibility for the maintenance of such a space. Due to having such a strong communal focus, partitions are often featured in open office contexts in order to reduce noise (Virjonen, P., et al., 2007) and to achieve the high incremental enhancement of having a baseline level of privacy.

As with many layout propositions ranging from stylistic to functional undertones, the emergent outcomes of a particular layout within an organizational or work culture context are complex. Even in circumstances where an identical layout methodology is implemented within various organizations, the resulting impacts on morale, productivity, and wellbeing may differ. For this reason, it is important to recognize that layouts should not be perceived as a singular design variable that entirely governs the outcomes of a hypothetical optimization problem. Rather, the emerging outcomes are a function of a multitude of variables at play, many of which are microscopically embedded within the organizational culture or macroscopically ingrained within the preferences/tastes of any given region of the globe. As such, there is tremendous value in establishing a connection between the preferences of a given time, the practices contained under the domain of these preferences, and the resulting reactions from the implementation and utilization of these practices.

4. Literature survey

A study conducted by Greg R. Oldham and Daniel J. Brass in 1979 discusses two primary approaches to perceiving the resulting impacts of implementing an open office plan (Oldham, G. R. & Brass D. J., 1979). In essence, this study examines the opinions, attitudes, and productivity of 81 employees throughout the transition toward an open office plan. The methodology of this study along with the corresponding results serves as the backbone for formulating the methods for perceiving the open office.

First, the authors identified the social relations approach which serves as a primary lens to capture the qualitative outcomes of a layout theory. This approach rises to a high level of prominence in open layout theories due to the strong emphasis on the fostering of productivity through social relations and interactions. Furthermore, the prevailing advantages and drawbacks of the widely accepted group development model (Egolf, D. B., 2013) become a critical point of interest. The social relations frame of reference provides valuable insight because it identifies interactions as the primary means of accomplishing the daily activities that support an organization or workgroup (Bonebright, D. A., 2010). Furthermore, the results of this study, show that both motivation and workplace satisfaction declined throughout the introduction of the open office layout plan that was featured in the study.

Second, the authors strategically identified the sociotechnical frame of reference for perceiving open office layouts and, more broadly speaking, layout theories at large. While this lens for perceiving an organization is frequently overlooked, a comprehensive understanding of the manifestation of socio-technical interactions is a critical ingredient of success within most modern-day technical organizations (Cherns, A., 1987). One common tendency is to reduce the dynamics of the operational function of an organization to a fixed set of metrics, reactions, solutions, or actions. The goal of this mindset is to pursue what is perceived to be a state of scientific operation at the expense of overlooking “softer” principles that are equally critical. A proper sociotechnical perspective, as indirectly implied by the authors of the indicated study, can lead to long-term growth benefits for an organization by recognizing the human

factors associated with the advancement of technical products.

Another study published in the Applied Psychology journal (Evans, G. W. & Johnson, D., 2000) examines 40 female workers who were exposed to noise levels that were intended to simulate the noise emerging from an open office environment. Fascinatingly, this study strategically applied a more cloaked technique for assessing the motivational outcomes of a workplace. One of the prominent tools that were applied for this purpose was measuring the number of attempts exerted towards an unsolvable puzzle. The introduction of workplace distractions led to an observable decrease in motivation coupled with a reluctance to make ergonomically beneficial shifts in posturing. Overall, the conclusions of this analysis are remarkably consistent with the findings of the previously discussed study and the generalized discussion of the open office characterization.

The fundamental concept of an open layout, regardless of whether the context is corporate or production, is rooted in a strategic lack of specificity in the functional activities that the space can accommodate. For this reason, open layouts are conducive to environments that require adaptability, interdisciplinary contributions, and customization. Naturally, this favors the notion of product variety rather than product volume. A study (James, O., et al., 2021) examines 31 papers and 238 outcomes for open office workspaces on the basis of five categories. A wide variety of other sources (Ilozor, B.D., 1999 and Alduaij, A. & Hassan, N.M., 2020) offer additional insights. Other studies provide excellent coverage of these outcomes in varying contexts (Lam, A. I. Y., 2014). As observed by the existing body of research literature (Bennett, D., 2015), the functional layout also goes by the name “process layout” designation. Although the functional layout assumes a variety of analogous forms depending on the application context (Groover, M. P., 2016), there are several underlying themes (Okpala, C.C. and Chukwumuanya, O., 2016) that help to characterize the operational tendencies of these layouts. The generalized results of these outcomes are depicted in Table 1 and Table 2.

Table 1. Assessment of Open Layout Outcomes

Open Layout Advantages	Open Layout Disadvantages
Product Variety/Customization (Positive)	Product Volume (Mildly Negative)
Ease of Access to Operators (Positive)	Batch Production (Mildly Negative)
Social Work Environment (Highly Positive)	Perceived Productivity (Mildly Negative)
Ease of Access to Materials (Positive)	Work Autonomy (Negative)
Communication (Highly Positive)	Worker Health (Mildly Negative)
Required Space for Facilities (Positive)	Workplace Satisfaction (Highly Negative)

Table 2. Assessment of Functional (Process) Layout Outcomes

Functional (Process) Layout Advantages	Functional (Process) Layout Disadvantages
Operational Flexibility (Positive)	Interdepartmental Communication (Negative)
Product Variety/Customization (Positive)	Cross-Functional Collaboration (Negative)
Batch Production (Sometimes Positive)	High Work-In-Process (WIP) (Negative)
Reduced Capital Investment (Positive)	High Inventory (Negative)
Reduced Overhead Cost (Mildly Positive)	Material Handling Demands (Highly Negative)
Favors Efficient Supervision (Mildly Positive)	High Production Gap (Negative)

5. Layout performance metrics

Consider a modern-day technical organization and the commonly desired outcomes for the operations of the company. The organization desires operational excellence at all levels while also holding a high standard for customer satisfaction. Ultimately, the principles of consistency, timeliness, and efficiency are critical. The system in this study is carried out within The University of Alabama in Huntsville Systems Management and Production Center (UAH SMAP Center) in the STEM outreach program. The layout of the STEM outreach program will be reduced into elemental components to facilitate analysis. The current state of the system is depicted in Figure 1 as shown below.

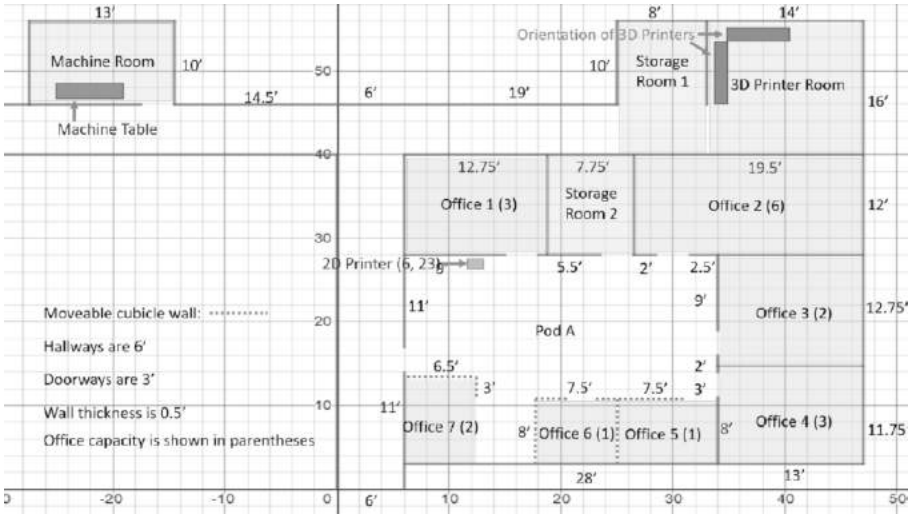

Figure 1. Current State of the UAH SMAP Center STEM Outreach Program Layout

To begin, a series of quantitative metrics will be proposed for assessing the effectiveness of a layout. Generally speaking, these principles should be universal enough to serve as an assessment tool for any arrangement of resources regardless of the strength of the direct or indirect ties to layout planning practices. In this case, the foundation of analysis will consist of deterministic demand values along with the corresponding distances between workstations (nodes) within the layout. Table 3 depicts the deterministic approximation of demand for a standard workday. The low levels of variability present across a significant sample of workdays indicate that the deterministic approximation of demand is a reasonable assumption.

Table 3. Total Demand Associated with Each Workstation

	3D Printers	Storage (Total)	2D Printer	Machines
Demand	41 accesses/day	20 accesses/day	16 accesses/day	3 accesses/day

At this point, the quantitative traits of the system must be manifested comparably. While distance provides the basis for a comparable measure, multi-objective optimization problems often translate all units into cost. Although this may call upon a variety of complex modeling techniques, the variables can be related to cost by invoking the labor wage rate along with the average walking speed (Montufar, J., et al., 2007). In the system of interest, the employees who perform all of the operational functions are paid at the rate of USD 12 per labor hour. The results of these calculations for each office are shown in Figure 2.

	Office 1	Office 2	Office 3	Office 4	Office 5	Office 6	Office 7	Average	Weighted Average
Distance to 3D Printers	64.21'	75.04'	78'	78.16'	75.71'	63.42'	60.16'	70.67'	71.82'
Distance to Storage Room 1	56.21'	67.04'	70'	70.16'	67.71'	55.42'	52.16'	62.67'	63.82'
Distance to Storage Room 2	5.5'	2'	11.72'	15.88'	17.59'	17.72'	22.02'	13.2'	9.94'
Distance to 2D Printer	3.35'	16.57'	23.24'	25.3'	24.52'	18.11'	15.51'	18.09'	16.97'
Distance to Machine Room	57.71'	68.54'	71.5'	71.66'	69.21'	56.92'	53.66'	64.17'	65.32'
Time Roundtrip to 3D Printers	28.99 s	33.88 s	35.21 s	35.29 s	34.18 s	28.63 s	27.16 s	31.91 s	32.43 s
Time Roundtrip to Storage Room 1	25.38 s	30.27 s	31.6 s	31.67 s	30.57 s	25.02 s	23.55 s	28.29 s	28.81 s
Time Roundtrip to Storage Room 2	2.48 s	0.9 s	5.29 s	7.17 s	7.94 s	8 s	9.94 s	5.96 s	4.49 s
Time Roundtrip to 2D Printer	1.51 s	7.48 s	10.49 s	11.42 s	11.07 s	8.18 s	7 s	8.16 s	7.66 s
Time Roundtrip to Machine Room	26.05 s	30.94 s	32.28 s	32.35 s	31.25 s	25.7 s	24.23 s	28.97 s	29.49 s
Cost Roundtrip for 3D Printers	$0.10	$0.11	$0.12	$0.12	$0.11	$0.10	$0.09	$0.11	$0.11
Cost Roundtrip for Storage Room 1	$0.08	$0.10	$0.11	$0.11	$0.10	$0.08	$0.08	$0.09	$0.10
Cost Roundtrip for Storage Room 2	$0.01	$0.00	$0.02	$0.02	$0.03	$0.03	$0.03	$0.02	$0.01
Cost Roundtrip for 2D Printer	$0.01	$0.02	$0.03	$0.04	$0.04	$0.03	$0.02	$0.03	$0.03
Cost Roundtrip for Machine Room	$0.09	$0.10	$0.11	$0.11	$0.10	$0.09	$0.08	$0.10	$0.10
								Total Daily Walking Cost (Demand-based, in $):	6.245074086

Figure 2. Current State Calculated Data

In surplus of these metrics, a valuable tool in guiding layout design is the utilization of centroids. Often invoked in the area of solid mechanics, centroids are used for assessing moments of inertia or mass centroids (Hibbeler, R. C., 2004). The understanding that inspired these theoretical developments may be seamlessly translated to the world of layout planning as shown in the formulas below.

$$C = (\bar{X}, \bar{Y}) \qquad (Eqn. 6)$$

$$\bar{X} = \frac{\Sigma_i x_i \cdot w_i}{\Sigma w} \qquad (Eqn. 7)$$

$$\bar{Y} = \frac{\Sigma_i y_i \cdot w_i}{\Sigma w} \qquad (Eqn. 8)$$

Thus, x_i depicts the location of a given point in the horizontal direction relative to the origin. Similarly, $_{Y}i$ represents the location of a given point in the vertical direction relative to the origin. w_i signifies a particular weight that is assigned to each locational coordinate. In this case, cost is the driving factor behind the quantitative analysis components of this study. The frequency that an employee travels along a specified route within the system serves as the proper weight to fulfill this stakeholder's desire.

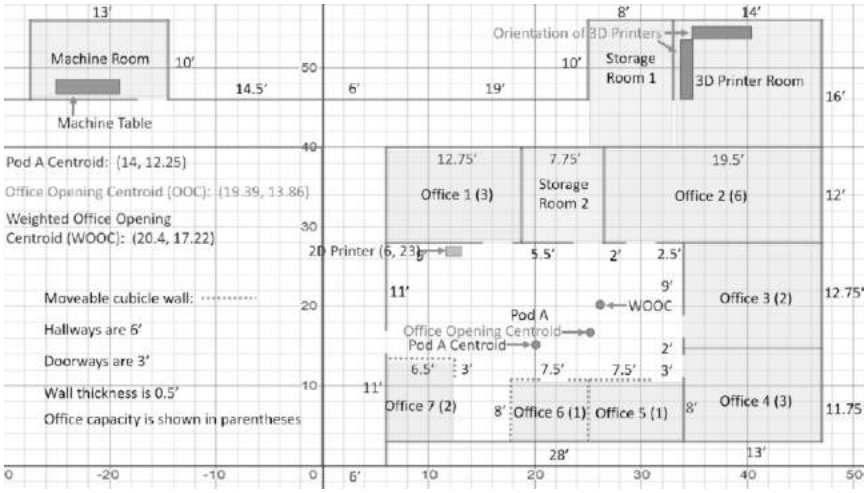

Figure 3. Initial State Centroids

In addition to these metrics, several qualitative implications are critical to consider. As noted in the brief literature survey, subtle changes to layout design practices may have profound impacts on morale, productivity, and longevity within a workspace. In leveraging these insights, qualitative factors are examined for the performance of the layout. The defined scope of these factors is provided below.

- Cost of Implementation
- Mechanical Flexibility
- Transparency of the Space
- Worker Privacy
- Overall Change from the Current State

Among the qualitative factors above, transparency uniquely holds a phenomenon known as the transparency paradox (Bernstein, E. S., 2012). Recognizing this paradox is beneficial because it identifies the connection between transparency and productivity levels (perceived and real measures). Most notably, this paradox holds strong ties to the observations emerging from the Hawthorne studies (Jones, S. R., 1992) which provided instrumental insight into the early comprehension of workplace psychological dynamics. Thus, except for transparency, all qualitative assessment criteria may be intuitively evaluated.

6. Results

Given this establishment, the valuable insights retained from the historical analysis of the foundational upbringings of open layout designs may be applied to the scenario of the UAH SMAP center. In incorporating this transformation, the weighted centroids shift relative to new system orientations. Likewise, both the qualitative and the quantitative factors are profoundly influenced by this rearrangement of resources within the system under consideration. In adherence to the true manifestation of open office theories, the resulting application is shown below in Figure 4.

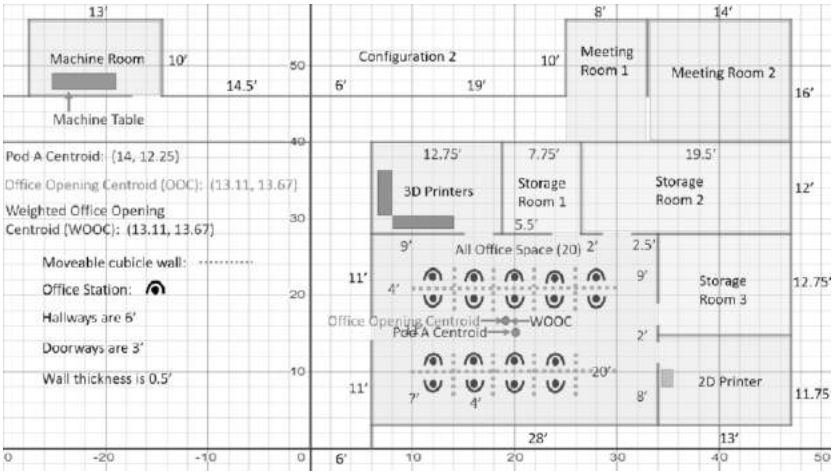

Figure 4. Open Office Manifestation of the System

Given this arrangement of resources, the perceived qualitative outcomes may be assessed in accordance with the current state conditions and the specific transformations required to truly achieve the essence of an open office plan. Simultaneously, it is important to recognize that complex systems frequently hold more opportunities to yield unexpected outcomes. The prevalence of this phenomenon increases with system complexity. Although the system at hand does not possess many of the common hallmarks of such a complex system, the noted phenomenon is nevertheless at play. The resulting impact on the qualitative criteria is depicted in Table 4. Table 5 considers the emerging layout in comparison to those of the original layout design under the prominent factors identified in the literature search.

Table 4. Qualitative Results for the Open Layout as Inspired by Theoretical Findings

Layout Qualitative Factors	Open Office Layout
Cost of Implementation	Good
Mechanical Flexibility	Excellent
Transparency of the Space	Excellent
Worker Privacy	Inferior
Overall Change from the Current State	High

Table 5. Assessment of Layout Qualitative Outcomes Based on Factors in the Literature Review

Open Layout Outcomes (Literature)	Current State Layout	Open Layout Manifestation
Product Variety/Customization (Positive)	Moderate	Good
Ease of Access to Operators (Positive)	Poor	Great
Social Work Environment (Highly Positive)	Poor	Great
Ease of Access to Materials (Positive)	Moderate	Good
Communication (Highly Positive)	Moderate	Great
Required Space for Facilities (Positive)	Moderate	Great
Product Volume (Mildly Negative)	Good	Poor
Batch Production (Mildly Negative)	Good	Poor
Perceived Productivity (Mildly Negative)	Good	Moderate
Work Autonomy (Negative)	Great	Inferior
Worker Health (Mildly Negative)	Good	Moderate
Workplace Satisfaction (Highly Negative)	Great	Poor

As shown in the previous tables, the qualitative factors identified in the literature search cast a distinct light upon the differences between the original layout and the manifestation of the open office concept. Most strikingly, the expected outcomes share some harmony with the expectations formed from the literature review. However, as previously noted about the complexity of systems and interactions, the expected results do not precisely align with the qualitative outcomes. This aligns with the original hypothesis that the results would depart from expectations, but only to a moderate magnitude.

After this, the quantitative results are compiled based on the performance metrics that were previously introduced. Most notably, there appear to be improvements of varying magnitudes in all quantitative assessment categories. The results of this analysis are shown below in Table 6.

Table 6. Quantitative Results for the Open Layout as Inspired by Theoretical Findings

Open Office:	Average Distance	Average RT Time	Average RT Cost ($)	Daily Cost of Walking Time ($)
3D Printers (41 accesses/day)	18.16’	8.2 s	0.027336135	1.120781546
Storage (20 accesses/day)	17.56’	7.93 s	0.026432546	0.528650839
2D Printer (16 accesses/day)	15.61’	7.05 s	0.023488207	0.375811318
Machines (3 accesses/day)	53.79’	24.28 s	0.080949326	0.242847977

The culmination of these results depicts the tremendous value in strategically capturing the advantages of open layout theories while making strides to minimize the drawbacks. In the application under consideration, the total daily walking cost, as mathematically defined in the previous section, is reduced from $6.25 to $2.27. This results in a very significant 63.6819% decrease in this cost metric.

7. Concluding remarks

The qualitative results of this analysis indicate that the overall state of the system declines when an open layout plan is implemented. These findings are in agreement with the literature and historical survey conducted in previous sections. The quantitative results indicate very significant gains based on the cost metric that was applied. While some organizations may be tempted to scoff at such a small dollar amount in the context of cost savings, this study was conducted in a system of part-time student employees who make only slightly more than minimum wage. If these same principles are considered in the context of a sophisticated and high-compensated network of employees, then the quantitative gains would be enormously impactful. Even small operational improvements may translate to significant advantages in global competitiveness when maintained over an extended period of time.

The supporting work for this study that is not included in this paper features an analysis using stochastic simulation (using Simio simulation modeling), hypothesis testing, layout effectiveness (Groover, M. P., 2016), the incorporation of task duration to assess the concentration of non-value added activities and lean wastes, and a comprehensive comparative evaluation of the outcomes emerging from two other layout theories. Encouragingly, there are a wealth of opportunities for further research.

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3D Printed Superhydrophobic Structures for Sustainable Manufacturing Benefits: An Overview

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Abstract

Superhydrophobic properties have been present in nature for many millennia before human beings discovered their true capabilities and utilized them to revolutionize modern societies. The most familiar form of hydrophobicity found in nature is that of the lotus leaf, where its ultra-low water adhesion and self-cleaning properties make it one of the best hydrophobic elements formed naturally. Since its discovery, artificially created superhydrophobic elements have been used in many industries—maritime, automobile, and medical—due to their self-cleaning, antibacterial, and corrosion-prevention properties. However, for a surface to become superhydrophobic, it must possess a greater roughness. To achieve this, microscopic- or nanoscopic-level modifications must be made to the surface through various experimentations. For a surface to be considered superhydrophobic, it must have a water contact angle greater than 150°. One cost-effective method of manufacturing superhydrophobic materials is three-dimensional (3D) printing (additive manufacturing), which has been gaining popularity in the recent past. A 3D printing design is initially created using computer-aided design (CAD) software. Then, the design information is transferred to a 3D printer through digital slicing of the CAD design. 3D printing allows the printing of objects with various functionalities at pre-designed locations in the object, so it is important to investigate these phenomena. This paper provides an overview of several studies that were conducted to achieve superhydrophobicity through the 3D printing process. The following section of the manuscript includes an introduction, literature review, methods of increasing surface roughness for superhydrophobicity, market-available 3D printing materials, and their applications, discussion on 3D printing technologies and concluding remarks.

Keywords: Superhydrophobicity, surface structure, additive manufacturing, topography

1. Introduction

Superhydrophobicity has been gaining recognition during the past few years, especially since the Corona Virus pandemic of late 2019. From the beginning of the pandemic, researchers and companies across the world have been working relentlessly to develop new remedies and materials that could save thousands of lives from the grips of the virus. Superhydrophobicity is one such phenomenon that could be implemented in the creation of microbe-resistant materials. The best instance of naturally occurring superhydrophobicity can be found in the lotus leaf. For a surface to be classified as superhydrophobic, it

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must possess a water contact angle greater than 150° (Uddin et al., 2021). To achieve this state, alterations must be made on a surface at a microscopic/nanoscopic scale through various techniques that lead to greater surface roughness which in turn increases the hydrophobicity. Superhydrophobic materials are sought after in many industries—automobile, naval, aerospace, and biomedical—due to their many desirable properties. These properties include antibacterial, corrosion-resistant, de-icing, drag reduction, and self-cleaning, and they mainly arise due to the water-repelling characteristics of superhydrophobic materials (Ijaola et al., 2020).

Consequently, superhydrophobic materials can be an asset in the medical field. For instance, equipment such as surgical masks, surgical gloves, and other surgical tools could be manufactured using superhydrophobic material, thereby preventing the buildup of dirt and microbes on their surfaces, which is of paramount importance to patients and health care workers (Subeshan et al., 2021). Also, parts of ships created using superhydrophobic materials could help reduce or prevent corrosion, which is crucial in salty environments. Moreover, superhydrophobic coatings can reduce a ship's drag forces, which occur as the result of friction generated between a moving ship and water, thereby slowing its speed. Superhydrophobic materials are also extensively used in the aerospace industry (Subeshan et al., 2022). Composites comprised of aluminum and superhydrophobic coatings are employed to manufacture planes since they assist in the prevention of ice buildup in airplane parts, such as wings, which can have catastrophic consequences during mid-air flight maneuvering (Baddam et al., 2021). In addition, superhydrophobic coatings are used in such automobile parts as windscreens and mirrors to protect against water droplet buildup during extreme weather. One low-cost and efficient method to produce superhydrophobic materials is through three-dimensional (3D) printing (additive manufacturing).

2. Literature Review

Yang et al. (2020) devised an experiment to enhance the hydrophobicity of polylactic acid (PLA) and acrylonitrile butadiene styrene (ABS). They managed to form hydrophobic coatings on parts of PLA and ABS through the fused deposition modeling (FDM) of 3D printing. Later, the hydrophobicity and surface roughness of the samples created, along with the effects of the 3D printing parameters on the samples, were measured. Based on the results, they concluded that the surface roughness of the 3D-printed samples was notably affected by the filling method and layer thickness. They also found that surface roughness was not affected by the printing speed. Additionally, the wettability of the samples was determined through an orthogonal experiment analysis technique, and the maximum observable water contact angle was 104.6° at a maximum sample layer thickness of 0.25 mm (Yang et al., 2020).

Lee et al. (2019) succeeded in creating superhydrophobic surfaces through the 3D printing technique. In this experiment, samples containing surface structures of various patterns were produced through an FDM 3D printer using a polylactic acid (PLA) filament. Later, the samples were dip-coated in methyl ethyl ketone and hydrophobic silica nanoparticles to form hydrophobic coatings that possessed nanoscale structures. The wettability of the samples was then determined, and a maximum water contact angle greater than 150° was observed.

Kaur et al. (2020) achieved superhydrophobicity through the digital light processing (DLP) method. They initially created a unique ink composed of photocurable acrylates and dispersed silica nanoparticles to produce objects with specific microstructures. The sample surfaces consisted of several micron pillars immersed in submicron hydrophobic particles. During experimentation, it was discovered that superhydrophobicity was achievable for certain dimensions within the structure, and the greatest superhydrophobicity was attained at pillar side lengths less than 100 µm, interpillar spacings ranging from 200–300 µm, and a height four times the side length. A floating test was conducted to further confirm superhydrophobicity. This was carried out by submerging superhydrophobic and non-superhydrophobic samples in water. Here, the superhydrophobic sample floated to the top, while the non-superhydrophobic

sample remained submerged at the bottom, thus proving superhydrophobicity. Finally, wettability testing revealed a water contact angle of 155° at a side length of 70 μm and an interpillar spacing of 300 μm.

Yang et al. (2018) managed to obtain superhydrophobicity through the immersion surface accumulation process (ISAP). Initially, superhydrophobic, microscopic, artificial hairs consisting of eggbeater-shaped heads were formed via the ISAP process. Multi-walled carbon nanotubes were then added to improve the surface roughness and mechanical strength of the resin. During testing, it was discovered that hydrophilic surfaces could mimic hydrophobic surfaces under the correct microstructural features. Wettability tests were then conducted, and a water contact angle of 170° was achieved.

Kang et al. (2019) fabricated superhydrophobic surfaces through the FDM process. A PLA mold was initially created using several printing angles ranging from 0° to 90° and a low printing resolution of 400 μm. The mold was then utilized in the surface casting of polydimethylsiloxane (PDMS) polymers with waveform patterns. Finally, water contact angle testing revealed a water contact angle of 160° at a printing angle of 70°, which was a 52.3% percent increase in the water contact angle when compared to a flat-surfaced PDMS polymer.

Zhang et al. (2020) created 3D polytetrafluorethylene (PTFE) microstructures and tested them for superhydrophobicity. Initially, PTFE nanoparticles were mixed in a photocurable solution of polyethylene glycol diacrylate, and the mixture was used to create a predefined microstructure through 3D microprinting. The microstructure was fabricated one layer at a time through exposure to ultraviolet (UV) lithography. The samples were then sintered to remove any impurities and obtain pure PTFE. Finally, wettability testing revealed a water contact angle of 151.8°, thereby confirming superhydrophobicity.

He et al. (2017) constructed superhydrophobic surfaces with the aid of a homemade 3D printer. Here, a polydimethylsiloxane ink was used to etch various geometric patterns onto a glass substrate. During experimentation, it was discovered that by adjusting the 3D printing parameters such as filament spacing and printing speed, it was possible to achieve superhydrophobic structures. Later the printed structures were peeled off the substrate, and their water contact angles were tested. Results indicated that a water contact angle of 154.9 °was achievable at a filament spacing of 0.80 mm and a printing speed lower than 1.0 mm/s.

Yuan et al. (2017) were able to achieve superhydrophobicity through a combination of techniques such as 3D printing, solution immersion, and heat treatment. Initially, polysulfone (PSU) membranes were formed via 3D printing. These PSU membranes were then immersed in a solution containing candle soot (obtained by scraping a burned metal plate) and hexane, and then mixed in a sonicator. These membranes were placed in an oven for 10 min at 60°C to remove any hexane on the surface. Later, they were rinsed again in hexane to remove any excess soot particles and further dried. Finally, the water contact angle was measured, revealing 161°.

Laser-induced breakdown spectroscopy (LIBS) is a kind of atomic emission spectroscopy that utilizes an intense laser pulse as the excitation source. Patole (2021) used LIBS to verify biofouling's elemental composition via examining the sample's spectral emission. Here, a 1 MHz femtosecond laser from Clark MXR was used. The biofilm samples were gathered by suspending Stainless Steel grade 316 plates with a depth of 1m in the field of Pascagoula Bay intended for 5, 10, 15, and 20 days. As a result, the significant elements visible in the LIBS spectra are Mg, Al, Ca, Si, Ba, Br, Fe, N, S, Na, and so. Additionally, this study will benefit in understanding the elemental composition of biofouling and work within the detailing of novel antifouling coatings (Patole 2021).

Figure 1 shows various methods to enhance surface hydrophobicity. Table 1 provides a summary of the literature review.

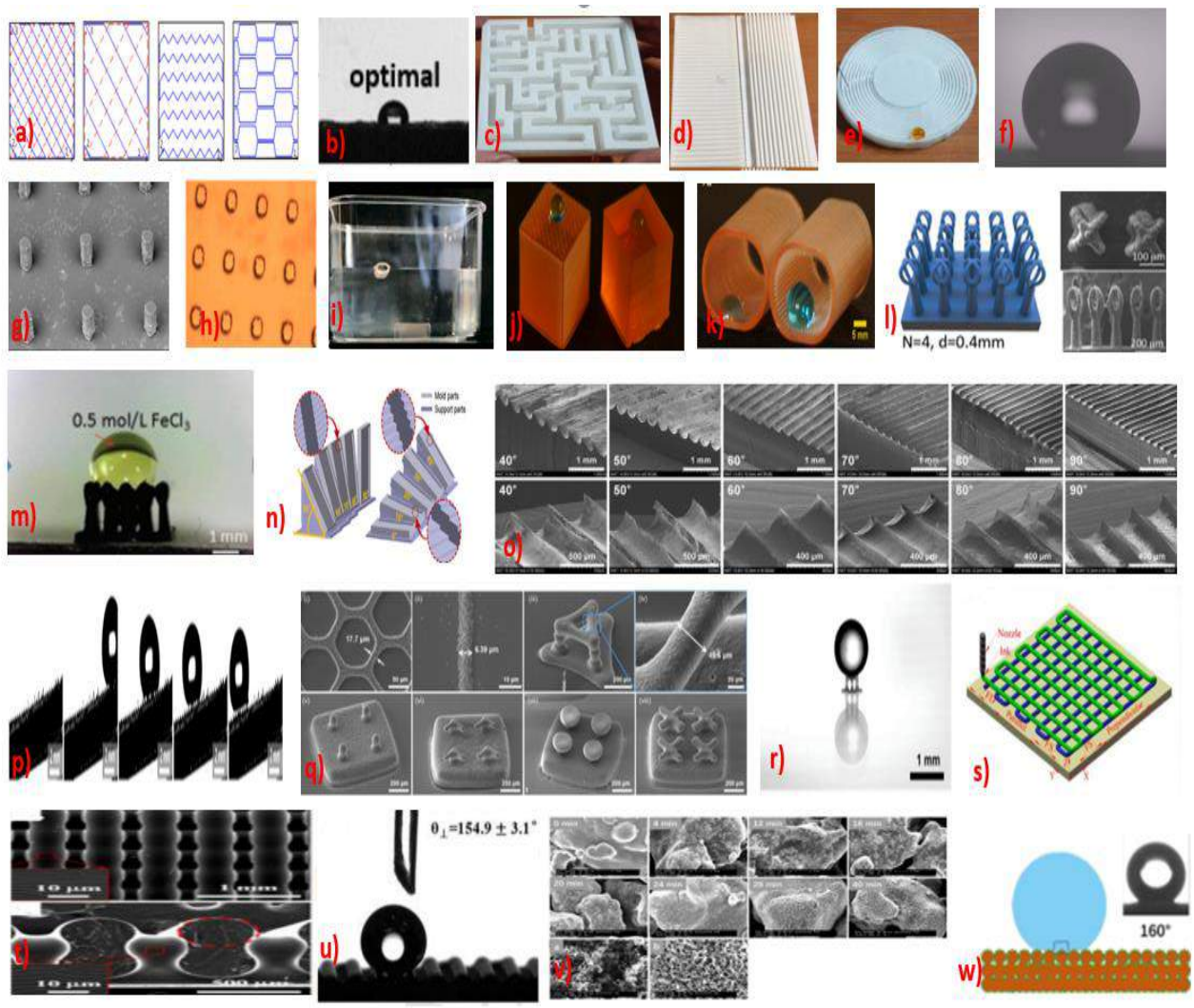

Figure 1: Various images revealing surface hydrophobicity: (a) various patterns of the filling method (left to right): rectilinear pattern, grid pattern, wiggle pattern, fast honeycomb pattern (Yang et al., 2020); (b) image of maximum water contact angle of 104.6° (Yang et al., 2020); (c,d,e) images of final product at various stages of experimentation (Lee et al., 2019); (f) maximum water contact angle of 161.5° (Lee et al., 2019); (g) scanning electron microscopy (SEM) image of micron pillars (Kaur et al., 2020); (h) optical microscope image of micron pillars (Kaur et al., 2020); (i) submersion test (Kaur et al., 2020); (j) cube-shaped superhydrophobic objects (left) and non-superhydrophobic objects (right) (Kaur et al., 2020); (k) cylindrical-shaped superhydrophobic objects (right) and non-superhydrophobic objects (left) (Kaur et al., 2020); (l) eggbeater-shaped structures (Yang et al., 2018); (m) maximum water contact angle of 170° (Yang et al., 2018); (n) CAD model of mold with various printing angles in experiment 5 (Kang et al., 2019); (o) SEM images of surfaces (waveform pattern) of PDMS polymers cast using PLA mold (Kang et al., 2019); (p) images of roll-off test conducted on PDMS polymer surface at printing angle of 70° (Kang et al., 2019); (q) SEM images of PTFE microstructures created via 3D printing (Zhang et al., 2020); (r) maximum water contact angle of 151.8° (Zhang et al., 2020); (s): 3D printing process (He et al., 2017); (t): SEM images at filament spacing of 0.60 mm (He et al., 2017); (u) maximum water contact angle of 154.9° [He et al., 2017); (v) SEM images of candle soot-coated PSU membranes (Yuan et al., 2017;) (w) maximum water contact angle of 160° (Yuan et al., 2017).

Table 1: Summary of Literature Review

References	Materials	Method(s)	Results WCA (°)	Bibliography
He et al., 2017	PDMS ink and glass substrate	3D printing	154.9	Fabrication of polydimethylsiloxane films with special surface wettability by 3D printing
Yuan et al., 2017	Polysulfone (PSU), hexane, and candle soot	3D printing, solution immersion, and heat treatment	161	Super-hydrophobic 3D-printed polysulfone membranes with switchable wettability by self-assembled candle soot for efficient gravity-driven oil/water separation
Yang et al., 2018	Resin and multi-walled carbon nanotubes	Immersion surface accumulation process (ISAP)	170	3D-printed biomimetic super-hydrophobic structure for microdroplet manipulation and oil/water separation
Kang et al., 2019	PLA and PDMS polymers	Fused deposition modeling (FDM)	160	Realization of superhydrophobic surfaces based on three-dimensional printing technology
Lee et al., 2019	PLA, silica, and methyl ethyl ketone	3D printing and dip coating	>150	Fabrication of superhydrophobic surface using FDM 3D printer with poly lactic acid (PLA) filament and dip coating with silica nanoparticles
Kaur et al., 2020	Photocurable acrylates, resin and silica nanoparticles	Digital light processing (DLP)	155	Fabrication of superhydrophobic 3D objects by digital light processing.
Yang et al., 2020	PLA and ABS	FDM and 3D printing	104.6	Preparation of hydrophobic surface on PLA and ABS by fused deposition modeling

References	Materials	Method(s)	Results WCA (°)	Bibliography
Zhang et al., 2020	PTFE and Polyethylene glycol diacrylate	3D-micro printing and sintering	151.8	3D μ-printing of polytetrafluoroethylene microstructures: route to superhydrophobic surfaces and devices
Dong, et al., 2021	Butyl acrylate (BA), lauryl acrylate (LA), and hexafluorobutyl acrylate/butyl acrylate (HFBA-BA) mixture	Digital light processing	152	3D printing of superhydrophobic objects with bulk nanostructure

3. Methods of Increasing Surface Roughness for Superhydrophobicity

3.1 Chemical Etching

The chemical etching process, shown in Figure 2, utilizes a strong chemical solution (etchant) to remove undesirable material from an object's surface via controlled dissolution, thereby creating a permanent-etched metal image. Through this process, surface roughness can be increased, thus giving rise to superhydrophobicity (Çakır et al., 2005)

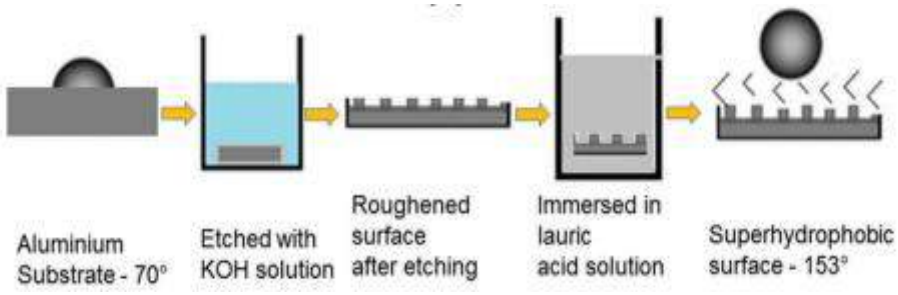

Figure 2: Chemical Etching Process (Varshney et al., 2016)

3.2 Solution Immersion

During solution immersion, as shown in Figure 3, a sample is immersed in a solution at room temperature for a certain time and dried. As a result, the surface roughness of the sample increases, creating superhydrophobicity (Wang et al., 2006).

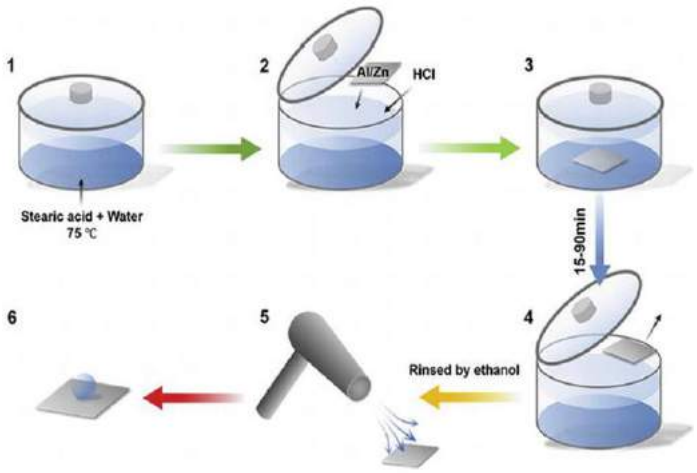

Figure 3: Solution Immersion Process (Ali et al., 2018).

3.3 Electrodeposition

The electrodeposition process, shown in Figure 4, creates a metallic coating through an electric current. The current is applied to a conductive material that is immersed in metallic salt, thus creating increased surface roughness and leading to superhydrophobicity (Liu et al., 2014).

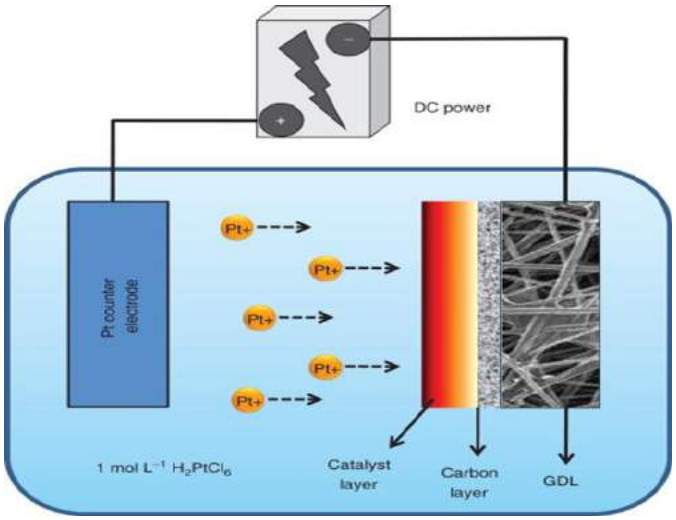

Figure 4: Electrodeposition Process (Liu et al., 2014).

3.4 Spray Coating

During spray coating, as shown in Figure 5, a stream of high-velocity particles in a molten or semi-molten state are deposited onto a substrate. This process has the ability to increase the surface roughness, thereby causing superhydrophobicity (Polizos, et al., 2018).

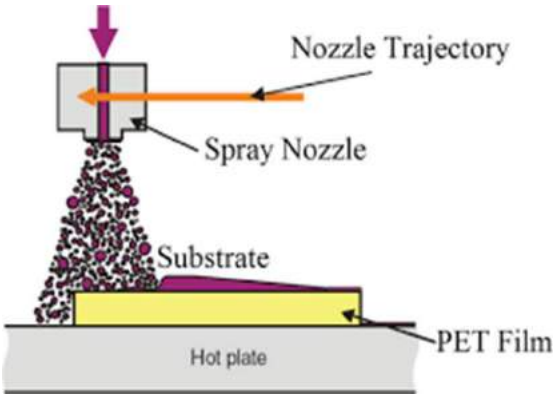

Figure 5: Spray Coating Process (Kooy et al., 2014)

The various methods of increasing surface roughness, discussed above, are commonly multi-stepped processes that require considerable time and resources. On the other hand, 3D printing (additive manufacturing) is a one-step process offering a faster and cheaper method of creating superhydrophobic surfaces with large surface roughness.

3.5 Digital Light Processing

DLP (Digital Light Processing) is a 3D printing innovation used to quickly create photopolymer parts. It's basically the same as SLA with one tremendous contrast where SLA machines utilize a laser that follows a layer, a DLP machine utilizes an extended light source to fix the whole layer on the double. The part is shaped layer by layer. DLP printing can be utilized to print very complex resin objects like jewelry and dental molds, toys and different things with fine subtleties. Since it restores the whole layer at once, it's a lot quicker than SLA (Mouzakis, 2018).

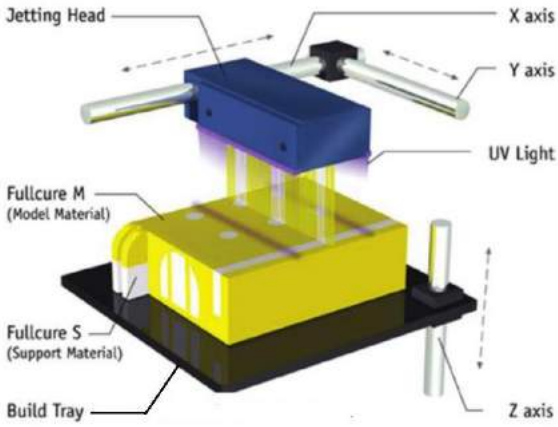

Figure 6: Digital Light Processing (Mouzakis, 2018)

4. Market-Available 3D Printing Materials and Their Applications

The 3D printing/additive manufacturing procedure uses a variety of techniques and materials that are currently available in the market to create a plethora of objects. One such technique is known as fused deposition modeling where materials such as thermoplastic filaments and continuous fiber-reinforced

polymers are utilized in forming objects with a layer thickness of 20–100 µm, such as advanced composite parts and rapid prototyping toys (Ngo et al., 2018). Another method used to develop objects via 3D printing is the digital light processing method. Here, a light source is projected into a resin tank using a digital micromirror device to form a patterned layer on the bottom of it. This method cures the entire platform simultaneously, forming an object with a layer thickness of 140–150 µm, using resins rather than filaments in printing objects (Kaur et al., 2020). The DLP method could be further modified to achieve objects possessing augmented nanostructures with virtually unrestricted freedoms of geometry (Dong et al., 2021). During this technique, an ink comprising porogen solvents and monomers of hydrophobic (meth) acrylate experiences a phase separation through the photopolymerization stage of the DLP process, which leads to the production of superhydrophobic and nanoporous structures.

Additionally, the immersion surface accumulation process uses resins in creating objects and employes a similar process as that in the DLP method. This method is used to etch 3D-microscale patterns of a high resolution onto macroscale surfaces at a thickness of 140–150µm (Yang et al., 2018; Subeshan 2018).

5. Discussion on 3D Printing Technologies

Additive manufacturing (AM) offers great opportunities compared to other traditional manufacturing methods. With AM, the production of any part can be started immediately, saving time and money (Ford and Despeisse, 2016). It also allows for more complex components and almost total design freedom. This design freedom also reduces assemblies by producing complex parts without assembly steps, compared to traditional manufacturing methods, and obviously reduces material losses (Lynn et al., 2018). Although AM is a breakout technology that can change production in various industries, the introduction of this technology is still in its infancy, and there are several challenges to applying AM in a way that allows for its significant and rapid development (Tofail et al., 2018). Numerous studies have shown the many obstacles to faster adoption, the largest of which is the cost of both material and systems, as shown in Figure 7. AM polymers and metals are still five times more expensive than their counterparts (Jiménez, et al., 2019). In most cases, the selection of a part's material, in combination with the specific process to be used, determines the geometric limits of the part design.

Another challenge is the lack of design knowledge related to AM. After using almost the same injection molding or extrusion method for more than 60 years, it is essential to change the manufacturing thought processes and start to design for additive manufacturing (DFAM) (Lee et al., 2017).

Another major challenge AM faces is the limited technical knowledge of the designers. Since AM technology is relatively new to most designers, a general understanding of its design is lacking, which creates considerable confusion when using AM processes (Jiménez, et al., 2019).

3D printers can only produce objects that are smaller than the size of the printer casing, which limits the size of items that can be manufactured. In addition, although there are larger printers, they must be housed in a large enough space to accommodate their size (Jiménez, et al., 2019). Consequently, in most cases, components manufactured with AM require secondary operations to create corresponding surfaces, which increases the cost.

Compared to traditional mass production, AM mass production is relatively slow. There is no changeover time between AM production lines and production output trails compared to conventional mass production run times. If printer production time cannot be improved when large quantities are required, traditional production is the preferred production mechanism. AM technologies are most often used to adapt mass production because they offer the possibility of creating highly customized products with a limited inventory (Jiménez, et al., 2019).

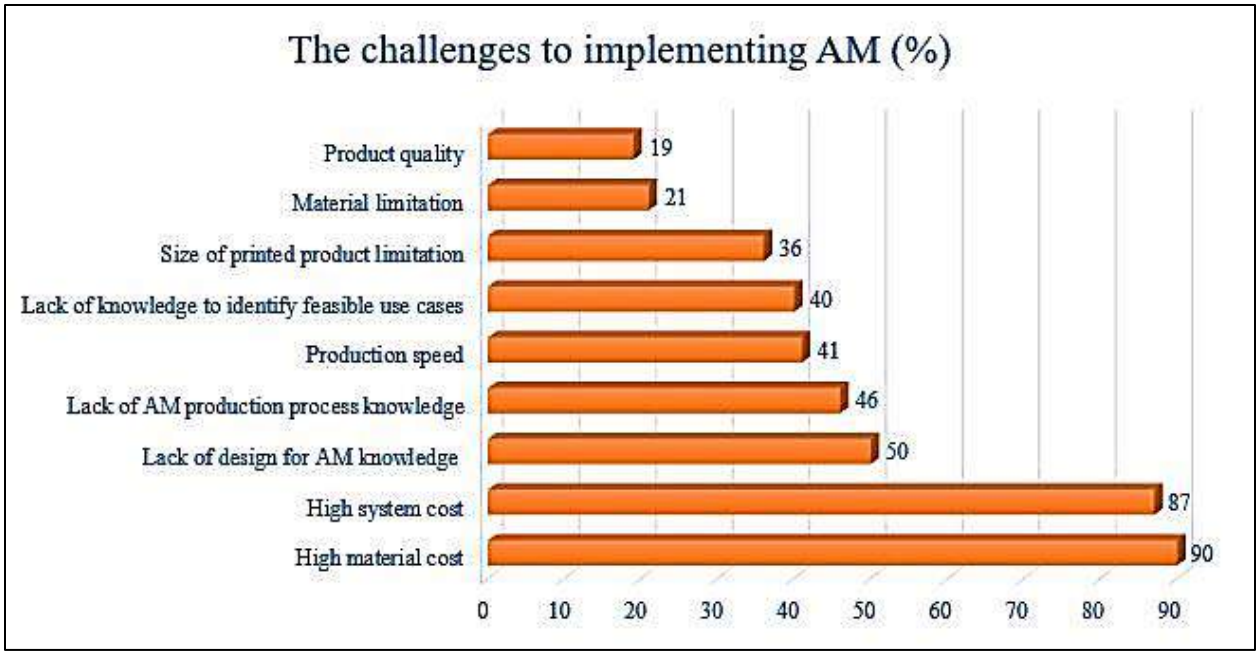

Figure 7: Most-recognized challenges to implementing AM.

5. Conclusions

This paper discusses several studies that were conducted to achieve superhydrophobicity via 3D printing. According to the research, it was evident that the digital light processing method is the best technique to produce superhydrophobic surfaces. The DLP method is much faster than the fused deposition modeling process since a single layer is cured instantly, unlike the FDM process which creates a single layer at a slow pace. The DLP method also produces objects with a greater resolution, which is not achievable via the FDM process, where accuracy is restricted due to nozzle size. Furthermore, the DLP method offers a smoother finish when compared to FDM. In subsequent testing utilizing 3D printing, eco-friendly chemicals and products could be used instead of the current chemicals and products, which are harmful to both human beings and the environment. Also, 3D printing could be used in the biomedical industry to create superhydrophobic surgical tools with favorable anti-bacterial and self-cleaning properties.

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Investigating the interaction between the Feedback Orientation & the Feedback Environment on Employee Performance

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Abstract

A positive relationship between a favorable feedback environment and employee performance has been established, thus, researchers and practitioners have been calling for a shift in focus from an annual performance review to using ongoing performance feedback necessary to create a favorable environment. This research seeks to validate the organizational importance of creating a favorable feedback environment, especially for those with a low feedback orientation, who may benefit more than those who already have a high feedback orientation. This study supports the previous findings indicating a favorable feedback environment is positively correlated with employee performance. These findings increase the need for continued exploration into relationships between the feedback environment, feedback orientation, and employee performance, specifically within different industries and organizational work settings (e.g., teams, or remote workers). A better understanding of the feedback process and its environment can assist organizations in developing their workforce and perhaps soften the decibels of the bullhorns calling for the elimination of employee performance reviews.

Keywords: feedback environment, feedback orientation, performance management systems, performance reviews, organizational effectiveness, employee performance

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1. Introduction

Organizations are investing billions of dollars trying to find the right performance management system to propel their employees to higher levels of achievement and foster the environment necessary for innovation and successful management. One of the primary factors that traditionally drives a company's decision-making process is organizational performance, resulting in leaders prioritizing the metrics used to measure performance in order to achieve their goal of organizational effectiveness (Folan & Browne, 2005; Leonard & Pakdil, 2016). Organizational effectiveness is connected to a plethora of factors including leadership, culture, employee performance, employee experience, feedback environment, business processes, etc. (Herold & Parsons, 1985; Martz, 2008). Research has shown that these factors positively impact employee engagement, operational costs, customer engagement and value, and organizational outcomes (Smith, 2019).

Despite its importance, organizational effectiveness and its criteria are ambiguous (Hoy & Hellriegel, 1982; Cameron, 1986; Schleicher et al., 2019). Companies attempt to control the myriad of factors that impact organizational effectiveness through their managers and a performance management system (Gross, 1969; Tovmasyan, 2017; Waal, 2012). These systems are often perceived as ineffective, making them frequent targets for improvement and innovation initiatives. These types of initiatives and changing organizational roles are two factors that contributed to the 'performance measurement revolution,' (Neely, 1999, p. 212-218; Leonard & Pakdil, 2016, p.95-107) where businesses rapidly evaluated the metrics they use to measure performance and redesigned their systems (Neely, 1999). Notwithstanding these efforts, *Sibson Consulting and World at Work* reported findings from a survey that stated that 58% of Human Resource Professionals gave their performance management systems a 'C' or below (Wharton, 2011). This is mainly due to the macro path research has taken to develop the model for organizational effectiveness. As a result, Human Resource professionals are overlooking individual behavior, specifically in the area of feedback, and attempting to determine organizational effectiveness in an environment with ever-changing metrics (Steers, 1975; Leonard & Pakdil, 2016, p.95-107; Rivera et al., 2021). Additionally, this constant updating and changing of their performance systems carries the burden of initial development and implementation costs, as well as the costs of 'improving' these systems when they fail to have the desired impact on performance. Considering the significant amount of resources put into failed improvements, the question we should be asking is whether the problem is broken performance management systems or the contexts in which performance feedback occurs, namely the feedback environment of the organization and the feedback orientation of the individual.

Humans live in an environment that is rich in feedback. For example, when we play a videogame on our smartphone, we get a score; when we send a text, we hear a sound that confirms a message was sent. Each example listed represents feedback and its integration into our daily lives. Feedback is the most utilized and ongoing provision in a performance management system (Leonard & Pakdil, 2016, p.95-107). Even with some practitioners' contradictory or love/hate views on performance management systems (Quinones & Sosa-Fey, 2018), there is at least one speculation that the performance management system itself is not the issue, but the context within which feedback occurs within the system; in other words, the issue is with the feedback environment (Anseel & Lievens, 2006; Levy & Williams, 2004; Pulakos & O'Leary, 2011). Feedback recipients work in various environments, some rich with information exchange, and others with little to no input. A performance management system without feedback is akin to playing the game of football without a football; you can have the most

efficient performance management system in the market, but it still comes down to the human factors of giving, receiving, and supporting feedback (Leonard & Pakdil, 2016, p.95-107).

Yet when we walk in the office door, we enter a 'no feedback zone' and only receive scheduled feedback once a year on our annual performance review (Leonard & Pakdil, 2016, p.95-107; Rivera, 2021). During this yearly performance review, employees receive information that allows the individual to know if goals are being met (London, 2003; Steelman, L. A., Levy, P. E., & Snell, A. F., 2004). However, the value of annual performance reviews and their feedback within the performance management system is questionable; and Daniel Pink (2010) has stated that performance reviews are rarely authentic. Moreover, Samuel Culbert (2010) stated that he does not find that annual performance reviews are constructive. The annual review is often this "one-sided accountable, boss-administered review" and, in reality, is not used correctly or accurately (Culbert & Rout, 2010, p. 146; Leonard & Pakdil, 2016, p.95-107). Understanding these interactions is key to creating an environment that promotes and supports employees at all levels in improving their performance, especially since a positive relationship between a favorable feedback environment and employee performance has been established (O'Malley & Gregory, 2011; Rosen et al., 2006; Whitaker et al., 2007).

It is important to note that, even with a positive feedback environment, individual differences may still influence this feedback interaction. Individuals respond to the same stimulus in different ways (Kluger & DeNisi, 1996; Rasheed et al. 2015), referred to as feedback orientation. Understanding these differences continues to be of practical and theoretical concern (Cianci et al., 2010). Organizations need a better understanding of what individual and organizational factors influence employees to be receptive to feedback in order to guide behavior change and increase employee performance (Herold & Parsons, 1985; Mahmud, & Azemi, 2019).

2. Hypothesis Development

The purpose of this study is to examine the extent to which the feedback environment influences employee performance and the extent to which an individual's feedback orientation moderates this relationship. The research presented explores the feedback environment, feedback orientation, and employee performance within the workplace.

2.1 Employee Performance

Feedback's association with improving performance has been an area of inquiry since the 1970's. Herold and Parsons (1985), and Ashford and Cummings (1985) were both early critics of the literature that focused on the annual performance appraisal. They challenged researchers to move beyond the type of feedback individuals receive annually from their superiors to understand how individuals seek and use feedback every day in their work lives. Most of the early studies hypothesized that providing performance-related information is better than withholding such information. Studies in organizational behavior have also addressed or attempted to understand how feedback influences performance (Herold & Parsons, 1985). Numerous studies have investigated the link between performance and feedback (Ilgen et al., 1979), and many of these investigations have supported this link (Becker & Klimoski, 1989). Whitaker, Dahling, and Levy (2007) found a positive correlation between the feedback environment and task performance (r =0.21) and contextual performance (r =0.16). The common assumption is that performance feedback will help guide and motivate future behavior and increase performance.

2.2 Feedback Environment

Over the years, there have been calls for developing a better understanding of an organizational culture that is supportive of feedback (Anseel & Lievens, 2007; London & Smither, 2002), and whether this organizational culture increases or decreases the difficulty in obtaining feedback. London and Smither (2002) proposed that a strong feedback culture exists when individuals continuously receive, solicit, and use feedback to improve their job performance (London & Smither, 2002; Heller, 2017; Evans & Dobrosielska, 2021). As a result, researchers stress that employees should have continuous access to performance feedback from multiple sources. Different cues can serve as feedback information, and available feedback is affected by a range of factors other than a performance episode (Ashford & Cummings, 1985; Herold & Parsons, 1985). Considering these variables, it is vital to develop a favorable feedback culture that could stimulate feedback openness among employees (Levy & Williams, 2004; Steelman et al., 2004).

More recent researchers refer to feedback culture as a feedback environment (Steelman et al., 2004). According to Steelman et al. (2004), the feedback environment refers to contextual day-to-day interactions between the supervisor with their subordinates and coworkers to coworkers rather than a formal performance appraisal process. An individual's perception of the feedback environment will channel through two sources, the coworker and the supervisor. Additional research indicates that the feedback environment can also be influenced by gender and source, (Rivera et al, 2021) and that a feedback-seeking culture can also moderate the impact on employee performance (Evans & Dobrosielska, 2021). Furthermore, the literature reveals that each source has seven specific facets: source credibility, feedback quality, feedback delivery, favorable and unfavorable feedback, source availability, and promotion of feedback-seeking (Steelman et al., 2004).

Whitaker et al. (2007) found that those who perceived they were in a favorable feedback environment had higher feedback-seeking behaviors, role clarity, and higher performance ratings than those in an unfavorable feedback environment. Previous research has also shown that when supervisors provide a favorable feedback environment for their employees, person-organization fit and organizational citizenship behaviors are enhanced (Peng & Chiu, 2010). Additionally, Rosen, Levy,& Hall (2006) found that when employees have greater access to information from a high-quality feedback environment, perceptions of politics are reduced, and performance outcomes are enhanced; and Peng, Mei-Man, and Ling (2011) found that deviant behavior is reduced when employees perceive a favorable feedback environment with their supervisor (Peng et al., 2011).

A favorable feedback environment is positively related to feedback orientation (Katz, Rauvola, & Rudolph, 2021), may stimulate feedback openness among employees, and may mitigate an individual's tendency to reject negative feedback by helping employees regulate negative emotions associated with a negative feedback message (Levy & Williams, 2004; Steelman et al., 2004). O'Malley & Gregory, (2011) argue that providing a favorable feedback environment aligns with factors related to positive psychology and should increase the likelihood of negative feedback acceptance and improved performance.

Given this detailed analysis on the extant literature discussing the relationship between employee performance and the feedback environment, our research empirically examines this relationship and posits that:

(H1): Perceptions of the feedback environment will have a positive relationship with employee performance.

2.3 Feedback Orientation

According to London & Smither (2002) feedback orientation is an individual construct including multiple dimensions that additively determine an individual's overall receptivity to feedback. Those with a strong feedback orientation (1) believe feedback has a positive effect and have low levels of evaluation apprehension, (2) have a propensity to seek feedback, (3) process feedback mindfully and deeply, (4) are sensitive to others' views of oneself, (5) believe that the feedback adds value and that they will become more effective with it, and (6) feel accountable to act on the feedback. Individuals with high feedback orientation will be more receptive to feedback and make constructive use of feedback until they have attained the competence they desire (Elliott & Dweck, 1988). In addition, individuals high in feedback orientation are likely to be receptive to coaching (London & Smither, 2002), especially in a non-favorable feedback environment, because they will seek to assimilate the feedback to enhance their behavior and performance, which then leads to a performance management cycle of receiving, absorbing, and applying feedback over time (London & Smither, 2002). In contrast, somebody low in feedback orientation may not exhibit these post-feedback behaviors.

Feedback orientation is also positively related to having a mastery orientation to learning versus a performance orientation (Dweck, 1986). Those with a mastery orientation towards learning focus on developing competencies and want to acquire knowledge and skills until they reach mastery; these individuals view skill deficits as opportunities. Alternatively, those with a performance orientation to learning compare their performance to that of others, see failure as indicating a lack of ability, and view performance feedback as threatening. Elliot and Dweck (1988) found that children who chose a mastery goal maintained a learning pattern of behavior over time while those who selected a performance goal performed well provided they had success, but displayed helplessness when confronted with failure .

An individual's feedback orientation depends upon the support and climate for learning. London & Smither (2002) adopt a person-environment interaction perspective for feedback processes, suggesting that feedback orientation develops over time and is shaped by organizational characteristics. Encouraging informal feedback or in-the-moment feedback will increase feedback frequency and support the formal feedback process, which suggests that an individual's feedback orientation may develop over time as feedback becomes more meaningful and valuable. For instance, suppose an organization creates a favorable feedback environment that encourages and supports feedback; in that case, an individual's feedback orientation may increase, and kick-start a healthy feedback cycle. London & Smither (2002) stated that an individual's feedback orientation is likely to stay stable in the medium term of 6 to 12 months but could shift over the long term as an individual acquires different experiences with feedback, shaped and supported by an organization's feedback environment.

Given the detailed analysis on the extant literature discussing the relationship between employee performance, the feedback environment, and an individual's feedback orientation, our research empirically examines this relationship and posits that:

(H2): An individual's feedback orientation will moderate the relationship between the feedback environment and employee performance.

3. Methods

3.1 Participants

Participants in this study comprised 155 employees from a medium-sized end-of-life healthcare organization located in the State of Florida who responded to a survey. This represented an overall response rate of 26% (of 596 total employees), with the age of the respondents ranging from 25 years old to 66 years old, and an average age of 48. The average job tenure was 4.97 years, and 86% of respondents were female, with 14% being male. The respondents worked within one of four main job families, comprised of 28% office, 32% field, 13% inpatient, and 27% facility. Additionally, 38% were classified as exempt while 62% were non-exempt. The respondents typically worked in interdisciplinary teams that provided medical care, psychosocial, and spiritual support for patients, their families, and caregivers. Each team was comprised of a physician, nurses, nurse assistants, social workers, and spiritual and bereavement counselors, all of whom were fully trained in end-of-life care.

3.2 Measures

Feedback Environment: The feedback environment was assessed using a shortened version of the supervisor source Feedback Environment Scale (FES) (Steelman et al., 2004), using a 7-point Likert-type scale ranging from strongly disagree to strongly agree.

Feedback Orientation: Feedback orientation was assessed using a twelve-item Feedback Orientation Scale (FOS), which evaluates an individual's feedback orientation (Linderbaum & Levy, 2010). The instrument is measured on a 7-point Likert-type scale from strongly disagree to agree strongly.

Performance: Supervisors were asked to complete a one-page evaluation form regarding various performance dimensions for their participating subordinates. This data was collected using Williams and Anderson's (1991) seven-item measure of in-role behavior.

3.3 Procedure

Participants received a link to a web-based survey that included the FES and the FOS, with a paper-and-pencil version being provided to those who did not have email access. The organization's management staff was not present during this process but were separately asked to complete paper-and-pencil measures of their subordinates' job performance and feedback-seeking frequency. These evaluations were returned in a self-addressed postage-paid envelope. All participants and managers were given a time frame of two weeks to complete the survey.

4. Results

Descriptive statistics and correlations for this study may be found in Table 1 and Table 2. Our null hypothesis implicitly stated that the perceptions of a favorable feedback environment would have no relationship with employee performance. Using a commonly accepted 95% confidence interval, our alternative hypothesis (H1) predicted that perceptions of a favorable feedback environment would be positively related to employee performance. Our empirical tests found evidence to support our alternative hypothesis (H1) and indicate that there is a positive relationship between a favorable feedback environment and employee performance ($r=0.23$, $p<0.01$).

Additionally, we hypothesized in (H2) that an individual's feedback orientation would moderate the relationship between the feedback environment and employee performance such that the relationship would be strengthened with a positive feedback orientation. Specifically, an individual with a low feedback orientation will seek less feedback than an individual with a high feedback orientation within the same feedback environment. To test this interaction, we followed Baron and Kenny's (1986) moderated regression procedures and applied them to test the impact of the feedback orientation on the relationship between the feedback environment and employee performance. The detailed steps to test this moderation effect and the results for each step, are as follows:

Step 1: Performance was regressed onto the feedback environment and was significant ($F(1,154>= 5.03$, $p < 0.5$)

Step 2: Feedback orientation was regressed on feedback environment and was significant ($F(1,154) = 9.83$, $p<0.1$)

In Step 3: Performance was regressed onto the feedback environment and feedback orientation interaction was significant. This significant interaction was found supporting our alternative hypothesis (H2), specifically, ($F(1,154) = 7.95$, $p<0.01$), ($\Delta R2=0.05$, $p<0.01$).

Thus, our empirical analyses provide support for both (H1) and (H2), with (H1) indicating a positive and significant relationship between perceptions of a favorable feedback environment and employee performance; and (H2) supporting the hypothesis that an individual's feedback orientation significantly moderates the relationship between the feedback environment and employee performance such that the relationship is strengthened with a positive feedback orientation.

5. Discussion, Limitations, and Future Research

This study investigated the theories regarding the existing relationships among feedback environment, feedback orientation, and employee performance. Past research suggests that a favorable feedback environment will lead to increased performance (O'Malley & Gregory, 2011; Rosen et al., 2006; Whitaker et al., 2007). Hypothesis 1 in this study was supported, strengthening the previous findings that a favorable feedback environment is positively correlated with employee performance. Hypothesis 2 was also supported indicating that feedback orientation moderated the relationship between the feedback environment and employee performance. The data indicated that individuals with a low feedback orientation working in a non-favorable feedback environment had lower performance levels than did those with a high feedback orientation working in the same environment, possibly indicating that an individual's orientation regarding feedback is more critical when the feedback environment is poor. Interestingly, the slope for the low-feedback-orientation individuals was steeper than for those with a high-feedback orientation, which, may further suggest the feedback environment is more critical for employees with low feedback orientation than for employees with high feedback orientation (see Figure 1).

These findings increase the need for continued exploration into relationships between the feedback environment, feedback orientation, and employee performance, specifically within different industries and organizational work settings (e.g., teams, remote work). London & Smither (2002) suggest a reciprocal relationship between the feedback environment and feedback orientation, and Gregory et al. (2008), posit the question; does a *supervisor's* feedback orientation affect the feedback environment?

Either way, it seems that these two are interrelated and deserve further exploration. A longitudinal study, which looks at an individual's feedback orientation over time in relation to the feedback environment, may shed light on the behaviors that influence the feedback environment as well as the direction of the relationship (e.g., feedback environment to orientation or reverse).

While the results of this study were supported, there were several limitations. The first was due to the timing and possible distractions during the assessment period, wherein the surveys were administered during nurses' week, which is an annual celebration of the nursing profession. There were times when completing the survey was the only thing between them and a free lunch or breakfast. In addition to nurse's week, the organization was undergoing 'open enrollment' for their company-provided healthcare benefits. While this survey was promoted by upper management as important and confidential, it may have been perceived by some as inconsequential to their daily work.

Another limitation was regarding the span of control for supervisors. There were significant differences in the performance ratings between supervisors with high versus low spans of control. The data indicate that those with a span of control of more than 20 were more lenient in their ratings compared to those with a lower span of control. Those with a high span of control represented roughly half of the sample, 76 out of 155.

Additionally, the nature of this sample is individuals working in a not-for-profit healthcare environment and working relatively independently. Most of their daily interaction is with the patients and their families, not with their supervisors. Also, this organizational setting has many indirect reporting relationships, where employees have daily interactions and receive direction from individuals with whom they work directly, but who are not their direct supervisors. These factors create a situation where the direct supervisor might not be an appropriate rater for individual performance.

6. Proposed Contributions

A better understanding of the feedback process can assist organizations in developing their workforce and perhaps soften the decibels of the bullhorns calling for the elimination of employee performance reviews. This study took another step following many others that highlighted the importance and strength of feedback orientation and its relationship with the feedback environment. We anticipate that the results of this study will spur additional interest and focus for both researchers and practitioners on this complex, and important, topic.

7. Tables & Figures

Table 1: Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis		K-S
							St. Error		St. Error	
Feedback Environment	155	2.05	6.71	5.22	0.99	-0.97	0.19	0.92	0.39	Sig
Feedback Orientation	155	3.75	7.00	5.88	0.74	-0.58	0.19	-0.14	0.39	Sig
Feedback Seeking	155	1.00	6.89	2.79	0.92	1.12	0.19	2.42	0.39	Sig
Inquiry Feedback Seeking	155	1.00	7.00	2.50	1.00	1.46	0.19	3.24	0.39	Sig
Inquiry Feedback (Supervisor)	155	1.00	7.00	2.49	1.02	1.39	0.19	2.95	0.39	Sig
Monitoring Feedback Seeking	155	1.00	6.67	3.36	1.14	0.30	0.19	-0.28	0.39	Sig
Negative Feedback Seeking	155	1.00	7.00	3.99	1.72	-0.28	0.19	-0.75	0.39	Sig
Positive Feedback Seeking	155	1.00	7.00	4.39	1.56	-0.38	0.19	-0.36	0.39	Sig
Employee Performance	155	3.29	7.00	6.65	0.68	-2.60	0.19	7.21	0.39	Sig
Supervisor Engagement	155	1.00	7.00	5.35	1.48	-1.07	0.19	0.65	0.39	Sig
Supervisor Pers. Pos FS	155	1.00	7.00	4.73	2.02	-0.55	0.19	-0.87	0.39	Sig
Supervisors Pers. Neg FS	155	1.00	7.00	5.31	1.71	-1.20	0.19	0.77	0.39	Sig
Length of Service (years)	155	0.00	22.00	4.97	4.34	1.40	0.19	1.97	0.39	Sig
Specific Performance Measure (HBTS)	155	2.00	5.00	4.34	0.82	-1.13	0.19	0.68	0.39	Sig

Table 2: Correlations between Variables

		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15
1.	Feedback Environment															
2.	Feedback Orientation	.25**														
3.	Feedback Seeking	-.08	.36**													
4.	Inquiry Feedback Seeking	-.03	.29**	.93**												
5.	Inquiry Feedback Seeking (Sup Only)	.13	.26**	.83**	.92**											
6.	Monitoring Feedback Seeking	-.13	.36**	.78**	.49**	.40**										
7.	Supervisor Engagement	.75**	.17*	.12	.16*	.33**	-.00									
8.	Employee Performance	.18*	-.05	-.07	-.05	-.02	-.08	.17*								
9.	Positive Feedback Seeking	.19*	.30**	.48**	.46**	.50**	.35**	.28**	.08							
10.	Negative Feedback Seeking	.10	.28**	.42**	.39**	.39**	.34**	.18*	-.03	.76**						
11.	Positive Feedback Monitoring	.08	.39**	.40**	.27**	.24**	.50**	.15	.06	.45**	.46**					
12.	Negative Feedback Monitoring	-.08	.40**	.34**	.21**	.17*	.45**	-.06	-.07	.32**	.54**	.66**				
13.	Supervisors Pers. Positive Feedback	-.10	-.04	.11	.05	.10	.18*	-.04	.23**	.02	-.02	-.08	.01			
14.	Supervisors Pers. Negative Feedback	.00	-.03	.10	.09	.12	.08	.06	.31**	.1	.0	-.1	.0	.61**		
15.	Length of Service	-.12	-.21**	-.11	-.09	-.12	-.12	-.08	.09	-.18*	-.14	-.16*	-.04	.22**	.12	
16.	Specific Performance Measure (HBTS)	.23**	-.11	-.16	-.12	-.08	-.17	.15	.77**	.02	-.02	-.01	-.15	.17*	.18*	.15

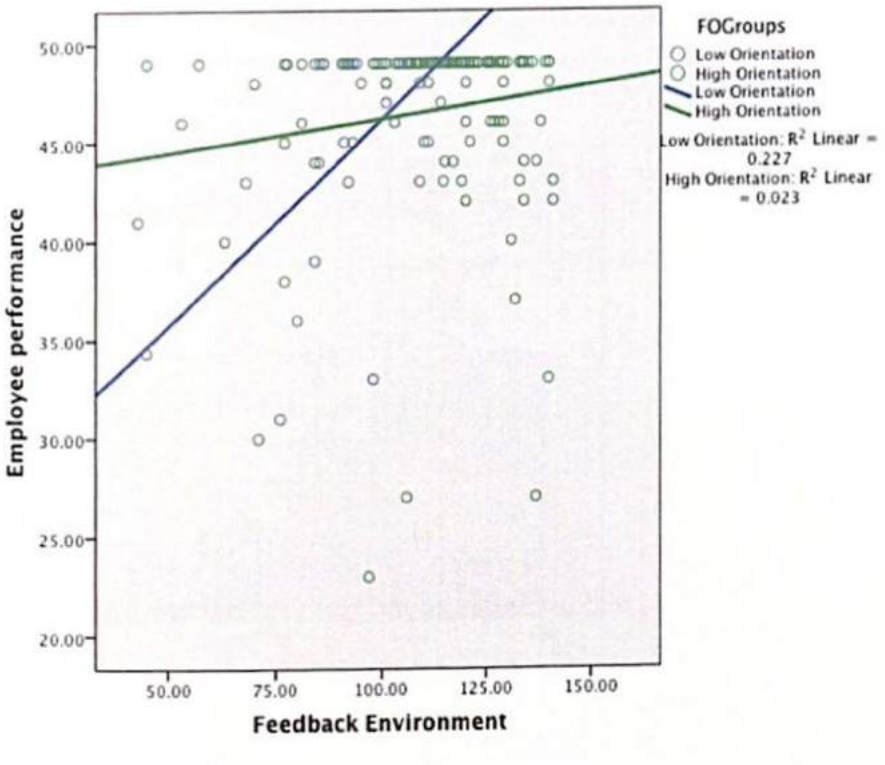

Figure 1: Feedback Environment-Orientation on Employee Performance

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