The McNair Research Journal is a multidisciplinary journal of undergraduate research conducted by the McNair Scholars cohort of 2019-2020.
Congratulations to the Ronald E. McNair
Scholars Cohort of 2019-2020

When I dare to be powerful—to use my strength in the service of my vision—then it becomes less and less important whether I am afraid – Audre Lorde

I am no longer accepting the things I cannot change; I am changing the things I cannot accept – Angela Davis
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April 23, 2020

When the inaugural issue of The McNair Scholars Research Journal of The University of Texas at Austin was published three years ago, the Division of Diversity and Community Engagement (DDCE) could not have been more proud of the students participating in the McNair Program and their research accomplishments. In this annual publication of the research journal, the McNair Scholars Program continues its record of excellence.

DDCE is honored to have the McNair Scholars Program as part of its portfolio and fully supports the program’s goal of increasing the number of low-income and first-generation college students in graduate school. This goal is consistent with the DDCE’s efforts to create an intellectually and culturally diverse environment at the university. Therefore, it is my pleasure to offer an introduction to this year’s issue of The McNair Scholars Research Journal of The University of Texas at Austin. The students published in this issue are McNair scholars who were selected to participate in the summer McNair Scholars Research Institute. These student scholars work with faculty mentors who support their research interests and guide them through the research project process that culminates in completing articles for publication in this, the McNair Journal. Not only does the journal offer a stepping-stone for the student scholars who want to seek out additional publication opportunities, but the journal also provides a venue for graduate programs to see examples of the student’s work.

As is evident in this issue, the research interests of the 2019 cohort of McNair Program scholars are as diverse as the individual students themselves. This annual publication marks the continuation of what we hope will be a successful pursuit of academic advancement followed by a fulfilling professional career. I have no doubt readers of the journal will recognize the value of the McNair Scholars Program and the opportunity it offers to participating undergraduates whose scholarly accomplishments are a reflection of what represents the best of The University of Texas at Austin.

Dr. Leonard Moore
Vice President for Diversity and Community Engagement
George Littlefield Professor of American History
A Message from the Directors

We are very pleased to present this year’s volume of The McNair Scholars Research Journal at The University of Texas at Austin. This journal is the culminating product of the efforts of our McNair Scholars during their Summer Research Institute. The scholarly research presented here is a testament to the hard work and dedication of our scholars. The *McNair Scholars Research Journal* represents a persistent tradition of our students achieving academic excellence.

The McNair Scholars Program prepares high-priority students for doctoral studies through involvement in research, faculty mentoring, academic colloquia series and other scholarly activities. Ever since our first cohort of scholars graduated in 2009 and entered into graduate programs, our program continues to prepare first generation college students from underrepresented backgrounds to diversify the academic environment.

This year’s journal contains the work of twelve students who completed the 2019 Summer Research Institute. We are very proud of the accomplishments of our McNair Scholars and we look forward to helping them achieve their academic goals and future endeavors.

We would like to thank all the McNair Faculty Mentors for their support, guidance, and expertise in working with our Scholars. Your participation as faculty mentors has truly enriched the academic careers and enhanced the potential of our students. This program is also dependent on the support of our incredible staff members who work very hard to allow us to put forth a quality program. We would also like to extend appreciation Dr. Leonard Moore, Associate Vice President for Diversity and Community Engagement for his unwavering commitment and support of the McNair Scholars Program.

With the support of all these individuals and the perseverance of the McNair Scholars we can continue to demonstrate that at The University of Texas McNair Scholars Program, “What Starts Here Changes the World!”

Thank you,

Dr. Darren Kelly
Director, McNair Scholars Program
Deputy to the Vice President

Dr. Anthony Brown
Faculty Director
McNair Scholars Program
Diabetes Status and Diabetes Control Independently Associated with Cognitive Impairment among Mexican Americans

Paola Bojorquez-Ramirez
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Francisco Gonzalez-Lima, PhD, Faculty Mentor
Leanne H. Field, PhD, Faculty Mentor

Objective: Findings on the association of diabetes and diabetes-related conditions with alterations in cognitive function have been inconsistent. Furthermore, no studies have evaluated the association between diabetes control and cognitive function among Mexican American adults, a population with a high burden of diabetes. The purpose of this study was to determine if diabetes status and control of diabetes is associated with cognitive function among Mexican American adults aged ≥18 years in the Cameron County Hispanic Cohort (CCHC), as well as examine changes in cognitive function during a median follow-up of five years.

Methods: The cross-sectional analysis included 2991 participants 18-94 years of age from the CCHC. Mini-Mental State Examination (MMSE) scores were dichotomized as an indication of ‘mild to severe’ cognitive impairment (MMSE ≤24, n=333, 11.13%) or normal cognition (MMSE>24, n=2658, 88.87%).1 Logistic regression models were used to assess the odds of cognitive impairment with diabetes status using a multi-factorial variable based on the American Diabetes Association 2010 criteria and diabetes control based on HbA1c levels among participants with diabetes.

Results: At baseline visit, 16.14% of participants with diabetes and 8.64% of participants without diabetes were identified as having ‘mild to severe’ cognitive impairment. Participants with diabetes were found to have 2.04 (95%CI: 1.54-2.69) times the odds of having ‘mild to severe’ impairment compared to participants without diabetes. However, the association between diabetes status and ‘mild to severe’ cognitive impairment attenuated in models adjusting for age and education (adjusted OR: 1.15[95%CI: 0.84-1.57]). Among those with diabetes (n=745), participants with poor diabetes control were found to have 1.65 (95%CI: 1.08-2.52) times the odds of having ‘mild to severe’ cognitive impairment compared to participants with good or adequate diabetes control. When adjusted for age and education, the association between poor diabetes control and ‘mild to severe’ cognitive impairment remained significant (OR:1.69 [1.10-2.60]).

Conclusion: In models not adjusting for age and education, diabetes status and diabetes control were independently associated with cognitive impairment among Mexican Americans across a wide age range. This association attenuated for diabetes status, but remained significant for diabetes control when adjusted for age and education. Older individuals with
diabetes, particularly if not well controlled, are at increased risk of cognitive decline.

Background

Mild Cognitive Impairment (MCI) is a cluster of symptoms that affect memory, judgement, thinking and language beyond the normal age-related cognitive decline. Approximately 15 to 20 percent of people aged 65 or older have MCI. Moreover, approximately half of the people diagnosed with MCI will experience continued progression of symptoms, leading to Alzheimer’s disease (AD) or a similar dementia. There is no current cure for cognitive impairment and AD which accounts for an estimated 60-80% of dementia cases. Of adults with perceived cognitive impairment in five states, 3.8-7.8% were aged 18-49 years. Despite this, there are no studies reported on Mexican Americans aged 65 or below. Limiting cognitive function studies to adults typically 65 years or older has been suggested to skew the age of MCI to older years.

Due to the growing demand of care and imminent economic burden because of MCI, identifying risk factors for MCI is imperative. Aside from advancing age and lower education, factors most consistently associated with MCI include chronic conditions such as diabetes, heart disease, and stroke. Some associated causes of cognitive impairment such as diabetes are conditions that may be treated or prevented. A recent study on participants from the Atherosclerosis Risk in Communities (ARIC) Study—a non-Hispanic cohort—indicates that having diabetes, poor glycemic control, and longer diabetes duration are associated with incident cognitive impairment. Another study concluded that previously established risk factors for MCI among non-Hispanic cohorts may not be predictive of MCI among Mexican Americans.

Despite the surge in research over the last decade on MCI, there is a paucity of research into cognitive impairment among Mexican Americans, a population with a high burden of diabetes. However, one study showed that Mexican Americans appear to be diagnosed with AD and MCI at younger ages. South Texas in particular is a relatively ethnically homogenous population, with 98% of Cameron County Hispanic Cohort (CCHC) participants identifying as Mexican American. This allows for the unique opportunity to understand the association of hypothesized diabetes risk factors with cognitive impairment in Mexican Americans. Using the 2010 American Diabetes Association (ADA) definition, diabetes prevalence is nearly 3 times (29.7%) higher among the randomly selected cohort of Mexican Americans in the CCHC than the national Mexican American diabetes prevalence of 10.4%

Moreover, previous research on the association of diabetes with cognitive impairment in Mexican Americans has produced conflicting results. Considering that only a third of diabetes cases in the CCHC were diagnosed by self-reporting, a multi-factorial diabetes variable based on the ADA definition was used to capture all participants with diabetes that would have otherwise been undiagnosed with diabetes.

In this study, we aimed to examine the relationship between diabetes status and diabetes control with cognitive function at baseline and changes in cognitive function during a median follow-up of five years among Mexican American adults aged ≥18 years in the CCHC. Participants with diabetes were hypothesized to be at greater odds of cognitive impairment than
participants without diabetes. It was also hypothesized that, participants with poor diabetes control would experience greater odds of cognitive impairment than those with good diabetes control. Moreover, it was hypothesized that MMSE scores at baseline would decline during a median follow-up of five years.

**Public Health Impact**

Hispanics are one of the most ethnically diverse and fastest growing U.S. populations and are expected to reach 28% of the U.S. population by 2060. Cameron County in particular consists of 89.3% Mexican Americans. The proportion of the Cameron County population that is 65 years older is 13.5%, greater than that of Texas (12.6%). With a median age (28.8 years) substantially lower than the United States (36.4 years) and advancing age as the greatest risk factor for cognitive impairment, the large proportion of young adults in Cameron County are likely to become impaired as they age. Not only will there be a greater burden of disease due to the large uninsured population, but there will be an imminent economic burden. People with cognitive impairment report more than three times as many hospital stays as individuals hospitalized for some other condition.

Determining if control of diabetes is associated with cognitive function among Mexican Americans can help identify populations at risk of cognitive impairment. Once populations at risk of cognitive impairment are identified, policies recommending assessments to detect cognitive impairment can be enforced to encourage primary care physicians working with at-risk populations to adopt cognitive impairment assessments regularly. Proper management of cardiovascular risk factors, especially diabetes, among people with cognitive impairment can be recommended to reduce the risk of and be less likely to develop dementia through planning and potential intervention. Further tests to detect biomarkers (i.e. amounts of beta-amyloid and abnormal tau) for dementias such as AD can be administered to ascertain the presence or absence of AD in early stages. Despite an estimated 64 percent of patients benefitting from early detection of cognitive impairment and nearly all primary care physicians believing cognitive assessment to be beneficial, only half of seniors are being assessed and just one in seven is getting regular brief cognitive assessments. Ultimately, identifying cognitive impairment risk factors can mitigate the detrimental effects that cognitive impairment can progress to and lessen the burden of diseases in Mexican American populations.

**Research Methods**

Participants: The cross-sectional analysis included 2991 baseline participants 18-94 years of age recruited to the CCHC between February 2006 and February 2019. Among baseline participants, data from participants with 5-year follow-ups (n=666) were used for the longitudinal preliminary analysis. The CCHC is an ongoing prospective population-based cohort that employs household recruitment through two-stage cluster sampling of households from randomly selected census tracts using Census 2000. Populations are sampled from the cities of Brownsville, Laredo, and Harlingen—all low-income and difficult-to-reach populations. Selected household participants are invited to visit the Clinical Research Unit (CRU) where written informed consents were obtained, questionnaires and examinations were administered, and specimens were collected, according to descriptive protocols. All study protocols were
approved by the University of Texas Health Science Center at Houston Institutional Review Board (IRB). CCHC offers us the unique opportunity to assess diabetes-related factors with cognitive function in a specific ethnic group—Mexican Americans.

Procedures: All CCHC participants in this study were administered either the Spanish or English Mini-Mental State Examination (MMSE) according to the participants’ preferred language, beginning February 2, 2006. The MMSE is a questionnaire that encompasses 0-30 points. It is extensively used across the literature as a screening measure of cognitive function. However, cut-off points for MMSE scores vary. MMSE scores were dichotomized in this study as an indication of ‘mild to severe’ cognitive impairment (MMSE ≤24, n=333, 11.13%) or normal cognition (MMSE>24, n=2658, 88.87%), according to ranges posted by the Alzheimer’s Association. Diabetes status was defined using a multi-factorial variable based on the ADA 2010 criteria; categorized as ‘Normal’ (no diabetes and MFBG <100 and HbA1c <5.7 and no diabetes medication), ‘Impaired’ (no diabetes and no diabetes medication and either 100 ≤ MFBG ≥ 126 or 5.7 ≤ HbA1c ≤ 6.5) or ‘Diabetic’ (yes diabetes or taking diabetes medication or MFBG ≥126 or HbA1c ≥6.5). Diabetes control was dichotomized as an indication of poor (HbA1c >9) or adequate and good (HbA1c≤9) diabetes control among participants with diabetes. The following cofounders were adjusted for: age at visit and education. Age at visit was categorized into the following categories: ’18-39 years,’ ’40-59 years’ and ’60-94 years.’ Moreover, education was categorized into the following categories: ‘< high school,’ ‘high school/GED graduate,’ and ‘> 12 years of education.’

Statistical analyses: Comparisons between the ‘mild to severe’ cognitive impairment and normal cognition group were conducted using unpaired two-sample t-tests for continuous variables or Pearson's Chi-square (χ2) Test for Independence for categorical variables. A series of logistic regression analyses using R (R Foundation for Statistical Computing) on baseline participants of the CCHC were conducted to examine the association between cognitive impairment as a function of diabetes status and diabetes control, adjusted for age and education. A descriptive analysis using Excel Version 15.26 was used to examine changes in MMSE scores as a measurement of cognitive function during a median follow-up of five years.

Results

Descriptive statistics for CCHC study participants are presented in Table 1. At baseline visit, 16.1% participants with diabetes and 8.6% of participants without diabetes were identified as having ‘mild to severe’ cognitive impairment. Among the ‘Mild to Severe’ cognitive impairment group, Mexican American participants were older (51.6 years vs. 42.9 years, P<0.001), had fewer years of education (7.4 years vs. 12.1 years, P<0.001), had higher HbA1c levels (6.1 vs. 5.9, P=0.04) and scored lower on the MMSE (21.9 vs. 28.4, P<0.001) compared to Mexican American participants with normal cognition. In terms of diabetes categorization, ‘Mild to Severe’ cognitively impaired participants were more likely to self-report having diabetes (P<0.001) and have a diagnosis of diabetes according to the ADA 2010 criteria (P<0.001). Furthermore, ‘Mild to Severe’ cognitively impaired participants with diabetes were more likely to have poor diabetes control (χ2=5.46 p=0.02) than participants with normal cognition. There was no significant association between gender and cognition categories (χ2=0.11, p=0.74).
A distribution of the 326 baseline participants who scored a 24 or below on the MMSE with diabetes status information is shown in Figure 1, according to impairment score interpretation. The number of participants with diabetes for each impairment category are also shown. The majority (79.4%) of ‘Mild to Severe’ cognitively impaired participants scored between a 21 and 24 on the MMSE, indicating having mild impairment, while only 1.2% of participants scored below a 13, indicating severe impairment. Furthermore, 19.3% of participants scored between a 13 and 20, indicating having moderate impairment. Out of the 2991 baseline participants with MMSE scores, only 2,921 had ‘ADA2010_Cat’ information to determine diabetes status. An age distribution for the 2,921 participants with diabetes status information is shown in Figure 2. The majority (82.1%) of participants were below the age of 60. Additionally, the ratio of participants with diabetes to participants with no diabetes began to even out among the oldest category of participants, as expected.

A series of logistic regression model results for diabetes status and diabetes control are shown in Tables 2 and 3. Participants with diabetes were found to have 2.04 (95%CI: 1.54-2.69) times the odds of having ‘mild to severe’ cognitive impairment compared to participants without diabetes in models not adjusting for age and education. Diabetes status remained significantly related to ‘mild to severe’ impairment when adjusted for education (adjusted OR: 1.65 [95%CI: 1.23, 2.20]) and age (adjusted OR: 1.38 [95%CI 1.02, 1.87]) independently, but this relationship attenuated when adjusted for both confounders. In models adjusted for age and education, participants with diabetes (adjusted OR: 1.21 [95%CI: 0.89,1.66]) no longer had a significant association with ‘mild to severe’ cognitive impairment. Age and education factors remained significantly related to ‘mild to severe’ cognitive impairment in all models looking at diabetes status (Table 2).

An age distribution for baseline participants with diabetes used to assess diabetes control is shown in Figure 3. The average age in years among Mexican Americans with poor and adequate or good diabetes control were 51.2 and 52.6, respectively. Among 745 participants with diabetes, participants with poor diabetes control were found to have 1.65 (95%CI: 1.08, 2.52) times the odds of having ‘mild to severe’ cognitive impairment compared to participants with adequate or good diabetes control, in unadjusted model. The odds for ‘mild to severe’ cognitive impairment increased for participants with poor diabetes control when adjusted for age (adjusted OR:1.72[1.12, 2.64]). In the model adjusted for education, the odds for ‘mild to severe’ cognitive impairment for participants with poor diabetes control remained around the same (adjusted OR:1.67[1.08, 2.59]). Moreover, when adjusted for age and education the association between poor diabetes control and ‘mild to severe’ cognitive impairment remained significant (adjusted OR:1.69[1.10, 2.60]).

Preliminary analyses showed no apparent change in cognitive function during a median follow-up of five years. Among the 666 baseline participants with 5-year follow-ups, 248 had an average decrease of 2.19 points on the MMSE and 263 had an average increase of 2.46 points on the MMSE. The remaining 155 participants had no change in their MMSE score. Five of the 666 participants with 5-year follow-ups had missing information for the ‘ADA2010_Cat’ variable. Out of the 621 participants with ‘ADA2010_Cat’ information, 73 participants whose average MMSE score decreased at 5-year follow-up had diabetes at baseline. Additionally, 61 participants with an increase in MMSE score at 5-year follow-up had diabetes. Among
participants with no change in MMSE score at 5-year follow-up, 34 participants had diabetes. Furthermore, the average MMSE score for the 666 baseline participants with 5-year follow-ups at baseline was 27.60. This average slightly increased to 27.75 at 5-year follow-up indicating no significant change in the delta MMSE between baseline and 5-year scores. The minimum MMSE score at baseline and 5-year follow-up was 16 (n=1) and 19 (n=3), respectively.

**Discussion and Conclusion**

We show that diabetes and particularly poor control of diabetes significantly determines the odds of cognitive impairment among Mexican American adults aged ≥18 years in the CCHC. This association is more significantly marked in the older population. We observed an attenuated association between diabetes status and ‘mild to severe’ cognitive impairment in models adjusting for age and education that may be a result of the confounding effect due to the inclusion of the wide age range. The relationship between poor diabetes control and ‘mild to severe’ cognitive impairment remained significant when adjusted for age and education. Further research is needed to ascertain that previously established risk factors for cognitive impairment among non-Hispanic cohorts such as diabetes may also be predictive of cognitive impairment among Mexican Americans younger than 60 years in the CCHC.

When examining the association between diabetes status and diabetes control with ‘mild to severe’ cognitive impairment, poor diabetes control was the significant factor for cognitive impairment among Mexican Americans that remained significant when adjusted for age and education. Participants with pre-diabetes had no significant association with the odds of having ‘mild to severe cognitive impairment.’ As previously observed in many studies, a lower attainment of education is associated with lower MMSE scores and cognitive decline. The odds of ‘mild to severe’ cognitive impairment were the greatest among participants who completed less than a high school or GED education compared to participants who obtained more than a high school education. These results suggest that established risk factors for MCI — age and education—hold true across a wide age range among Mexican Americans and indicate that the attenuated association observed among Mexican Americans between diabetes and ‘mild to severe’ cognitive impairment in models adjusting for age and education may be masked by the wide age range. While these findings cannot contradict previous studies that have found diabetes to be a risk factor for MCI in older adults, our results indicate that diabetes is not significantly associated with cognitive impairment across a wide age range among Mexican Americans in adjusted models.

On the other hand, Mexican Americans with poor diabetes control were at higher odds of ‘mild to severe’ cognitive impairment than Mexican Americans with adequate or good diabetes control in models adjusted for age and education. It is important to note that this significant association may be differ depending on the age distribution and stratification of participants. Our results were based on a younger age distribution of participants—the majority under the age of 60 years (Figure 3). Considering that advancing age is the most consistently associated factor with MCI, it is also important to note that the average age among Mexican Americans with good diabetes control was 4 years higher than the average age among participants with poor diabetes control. Thus, participants with poor diabetes control were at greater odds of having ‘mild to severe’ cognitive impairment than participants with good diabetes control, despite the higher age
average of participants with good diabetes control and overall younger age distribution. This strengthens the evidence for poor diabetes control as an indicator of cognitive impairment.

A lack of sensitivity using MMSE to capture cognitive impairment among minority populations, especially among younger populations where cognitive decline is not easily captured, has been reported due to strong influences levels of literacy, cultural and ethical norms, and language. Furthermore, the MMSE has been shown to be unreliable for patients with less than 5 years of education due to the heavy weight placed on mathematics and language abilities. Thus, a possible explanation for the high odds ratios for ‘mild to severe cognitive impairment’ observed for education can be due to over 8% of baseline participants having 5 or less years of education (Table 4). Another limitation of this study, is the potential for response bias that may occur at follow-ups among CCHC participants.

Prior knowledge of some aspects of the MMSE may explain the lack in apparent change in MMSE scores at 5-year follow-up. However, this bias is unlikely considering the long interval between the administration of the MMSE at baseline and 5-year follow-up. Further research is needed to examine longitudinal changes in MMSE scores according to diabetes status and control—perhaps, at 10-year follow-up—since the range for follow-up used may have been too short to detect cognitive decline.

Despite these shortcomings, the MMSE is used extensively and there is a substantial amount of evidence that supports its use as a measure of cognitive function. The Cameron County population has a large uninsured population, placing them at a higher risk for disease complications. Resource-poor communities like Cameron County with an estimated two thirds of all diabetes cases being undiagnosed have limited knowledge about cognitive impairment. For many participants, the CCHC is their only access to health diagnostics. For this reason, using the MMSE as an indication of a potential burden—cognitive impairment—related to diabetes may help stimulate policy and practice strategies to improve diagnostics of diabetes cognitive impairment among Mexican Americans in Cameron County.

Our findings suggest that having diabetes, specifically having poor diabetes control is a predictive factor of cognitive impairment among Mexican Americans across a wide age range. Both factors, diabetes status and diabetes control, were independently associated with ‘mild to severe cognitive impairment’; this association attenuated for diabetes status in adjusted models for age and education, but remained significant for diabetes control across crude and adjusted models. In light of the earlier onset of MCI among Mexican Americans and the large proportion of young adults in Cameron County that are likely to become impaired as they age, there is an inherent need to identify risk factors for cognitive impairment to improve chances of prognosis and prevention among an already overburden population.
Literature Cited


14. The University of Texas Health Science Center at Houston (UTHealth) School of Public


<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mild to Severe Impairment (MMSE ≤24, n=333)</th>
<th>Normal Cognition (MMSE&gt;24, n=2658)</th>
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<td>No. of Persons %</td>
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<td>HbA&lt;sub&gt;1c&lt;/sub&gt;&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.1(1.77)</td>
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<td>249 75.23</td>
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<td>21.9(2.49)</td>
<td>28.4(1.50)</td>
<td>P&lt;0.001*</td>
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Abbreviation: MMSE, Mini-Mental State Examination.

*Significant at P<0.05

<sup>a</sup> Values are expressed as mean (standard error).

<sup>b</sup> Percentages were calculated using the total observations for that specific variable.

† SR stands for self-reported
Figure 1. Distribution of ‘Mild to Severe’ Cognitive Impairment Baseline MMSE Scores, categorized by presence or absence of diabetes. Cutoff points for indication of severe, moderate or mild cognitive impairment were based on ranges posted by the Alzheimer’s Association. Among the 333 participants with scores ≤24, only 326 had diabetes status information.
Figure 2. Age distribution of baseline participants by, categorized by presence or absence of diabetes. Among the 2991 baseline participants, only 2921 had diabetes status information.
Table 2. Logistic regression models for cognitive function and diabetes status. Non-diabetes participants were used as the reference category.

### Baseline MMSE subgroups (0=Normal) as a function of diabetes

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<th>Explanatory Variables</th>
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<th>OR(95%CI)</th>
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<td>&lt;0.001*</td>
<td>2.036(1.539, 2.694)</td>
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### Baseline MMSE subgroups (0=Normal) as a function of diabetes adjusted for age (0=18-39)

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<th>Unstandardized Coefficients</th>
<th>P value</th>
<th>AOR(95%CI)</th>
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<td>1.381(1.018, 1.873)</td>
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<tr>
<td>Age at visit, years (40-59)</td>
<td>0.467</td>
<td>0.002*</td>
<td>1.595(1.184, 2.149)</td>
</tr>
<tr>
<td>Age at visit, years (60-94)</td>
<td>1.189</td>
<td>&lt;0.001*</td>
<td>3.282(2.368, 4.549)</td>
</tr>
</tbody>
</table>

### Baseline MMSE subgroups (0=Normal) as a function of diabetes(0=non-diabetic), adjusted for education (0=“>HS”)

<table>
<thead>
<tr>
<th>Explanatory Variables</th>
<th>Unstandardized Coefficients</th>
<th>P value</th>
<th>AOR(95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>-3.544</td>
<td>&lt;0.001*</td>
<td>0.029(0.019, 0.043)</td>
</tr>
<tr>
<td>Pre-diabetes</td>
<td>0.074</td>
<td>0.627</td>
<td>1.076(0.800, 1.449)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>0.499</td>
<td>&lt;0.001*</td>
<td>1.647(1.234, 2.199)</td>
</tr>
<tr>
<td>Education, years (&lt;HS)</td>
<td>1.848</td>
<td>&lt;0.001*</td>
<td>6.349(4.246, 9.493)</td>
</tr>
<tr>
<td>Education, years (HS/GED)</td>
<td>0.744</td>
<td>&lt;0.001*</td>
<td>2.104(1.294, 3.419)</td>
</tr>
</tbody>
</table>

### Baseline MMSE subgroups (0=Normal) as a function of diabetes, adjusted for age (0=18-39”) and education (0=“>HS”)

<table>
<thead>
<tr>
<th>Explanatory Variables</th>
<th>Unstandardized Coefficients</th>
<th>P value</th>
<th>AOR(95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>-3.757</td>
<td>&lt;0.001*</td>
<td>0.023(0.015, 0.036)</td>
</tr>
<tr>
<td>Pre-diabetes</td>
<td>-0.067</td>
<td>0.666</td>
<td>0.935(0.688, 1.270)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>0.191</td>
<td>0.231</td>
<td>1.211(0.886, 1.655)</td>
</tr>
</tbody>
</table>
Table 3. Logistic Regression Models for cognitive function and diabetes control among participants with diabetes. Good diabetes control (HbA1c≤9) was used as the reference category. (n=745)

<table>
<thead>
<tr>
<th>Explanatory Variables</th>
<th>Unstandardized Coefficients</th>
<th>P value</th>
<th>OR(95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline MMSE subgroups (0=Normal) as a function of diabetes control</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Constant)</td>
<td>-1.802</td>
<td>0.121</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Poor</td>
<td>0.500</td>
<td>0.216</td>
<td>0.020*</td>
</tr>
<tr>
<td><strong>Baseline MMSE subgroups (0=Normal, 1=CI) as a function of diabetes control, adjusted for age (0= ‘18-39’)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Constant)</td>
<td>-1.940</td>
<td>0.253</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Poor</td>
<td>0.544</td>
<td>0.218</td>
<td>0.013*</td>
</tr>
<tr>
<td>Age at visit, years (40-59)</td>
<td>0.003</td>
<td>0.282</td>
<td>0.991</td>
</tr>
<tr>
<td>Age at visit, years (60-94)</td>
<td>0.349</td>
<td>0.291</td>
<td>0.230</td>
</tr>
<tr>
<td><strong>Baseline MMSE subgroups (0=Normal) as a function of diabetes, adjusted for education (0= “&gt;HS”)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Constant)</td>
<td>-3.469</td>
<td>0.423</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Poor</td>
<td>0.512</td>
<td>0.224</td>
<td>&lt;0.022*</td>
</tr>
<tr>
<td>Education, years (&lt;HS)</td>
<td>2.160</td>
<td>0.431</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Education, years (HS/GED)</td>
<td>0.838</td>
<td>0.522</td>
<td>0.108</td>
</tr>
<tr>
<td><strong>Baseline MMSE subgroups (0=Normal) as a function of diabetes, adjusted for age (0= ‘18-39’) and education (0= “&gt;HS”)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant at P<0.05
<table>
<thead>
<tr>
<th>(Constant)</th>
<th>-2.251</th>
<th>0.326</th>
<th>&lt;0.001*</th>
<th>0.105(0.056, 0.199)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor</td>
<td>0.524</td>
<td>0.220</td>
<td>0.017*</td>
<td>1.688(1.098, 2.596)</td>
</tr>
<tr>
<td>Age at visit, years (40-59)</td>
<td>0.010</td>
<td>0.284</td>
<td>0.971</td>
<td>1.010(0.579, 1.763)</td>
</tr>
<tr>
<td>Age at visit, years (60-94)</td>
<td>0.385</td>
<td>0.296</td>
<td>0.194</td>
<td>1.469(0.822, 2.625)</td>
</tr>
<tr>
<td>Education, years (&lt;HS)</td>
<td>0.285</td>
<td>0.270</td>
<td>0.291</td>
<td>1.330(0.783, 2.260)</td>
</tr>
<tr>
<td>Education, years (HS/GED)</td>
<td>0.646</td>
<td>0.313</td>
<td>0.039*</td>
<td>1.908(1.033, 3.522)</td>
</tr>
</tbody>
</table>

*Significant at P<0.05

<table>
<thead>
<tr>
<th>Education, by categories (n=2981)</th>
<th>Mild to Severe Impairment (MMSE≤24)</th>
<th>Normal Cognition (MMSE&gt;24)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Persons</td>
<td>No. of Persons</td>
</tr>
<tr>
<td>≤5 years precollege</td>
<td>118</td>
<td>144</td>
</tr>
<tr>
<td>6 years precollege</td>
<td>55</td>
<td>302</td>
</tr>
<tr>
<td>7-11 years precollege</td>
<td>85</td>
<td>696</td>
</tr>
<tr>
<td>12 years precollege/GED</td>
<td>44</td>
<td>638</td>
</tr>
<tr>
<td>Technical/trade school&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9</td>
<td>157</td>
</tr>
<tr>
<td>College /University&lt;sup&gt;a&lt;/sup&gt;</td>
<td>19</td>
<td>655</td>
</tr>
<tr>
<td>Professional/graduate school&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1</td>
<td>58</td>
</tr>
</tbody>
</table>

<sup>a</sup> Years of education ranged between 1-4 years.

**Table 4. Observation counts of baseline participants by levels of education.**
Figure 3. Age distribution for baseline participants with diabetes (n=745) used to assess diabetes control.
Game Plan: A Multi-domain Review of Mobile App Rating Systems
Tailar Brown
The University of Texas at Austin
Ariane Beck, PhD, Faculty Mentor

In recent years climate change has become a very popular topic of discussion due to the extreme harmful effects that it has on the Earth and individual communities. Government incentive programs in combination with additional external efforts have been established in order to implement environmental intervention and increase environmental awareness. Of these efforts several mobile applications and serious games related to environmental behavior have been created to encourage pro-environmental behaviors (PEBs). These mobile applications utilize gamification to engage consumers and encourage behavioral change. In our research we reviewed the literature on application rating scales across various disciplines, in order to develop a comprehensive understanding of how to assess the quality of these apps. Our current research includes evaluating these application rating systems to determine the factors, such as quality, likability, engagement, usability, and efficacy, that are most relevant to designing quality apps. The findings from this project serve as a first step to develop a framework or rating scale for energy mobile applications to provide a tool to intervention designers when designing or selecting apps for their programs.

Keywords: Gamification, Mobile App, App Rating Scale, Environmental Behavior, Energy

Climate change and environmental behavior have become a very prevalent topic of discussion not only nationally but internationally in recent years. Energy consumption is one of the leading contributors to the greenhouse effect that magnifies the effects of global warming (Hedin et al). It is projected by the United Nation that within the next decade if we as a community continue to exhibit the same environmental behaviors that we are currently practicing, irreversible damage to the ecosystem will be the catastrophic result. While action at the organizational level, both government and corporate, will be necessary, an absence of leadership on these issues has led to emphasis on individual action. Pro-environmental behavior change has been studied extensively with numerous theories on behavior change, as well as studies on intervention design (Gardener & Stern et al.). One approach to intervention that have received increasing attention is the use of mobile apps.

At this point in time there are nearly 2 million apps, across a wide range of genres, present in both the App Store and Google Play store alike. In the past decade significant research

1 This article is a complete summary of the research that was conducted over the summer of 2019 in the EST Group under the supervision of research fellow Dr. Ariane Beck. The research group led by Dr. Varun Rai is housed in the Lyndon B. Johnson School of Public Affairs.
has been conducted on how to engage consumers, while at the same time promoting desired behaviors through use of mobile applications. A common motivational approach is to use gamification — the use of game principals in a non-game setting (Cugelman & Eppmann et al). This method allows for the customer to engage with an entertaining mobile application or serious game while at the same time encouraging a desired behavior or use of a service/product. In this case gamified applications would be used to encourage pro-environmental behaviors including energy conservation, alternative transportation modes, and increased awareness of environmental/climate changes.

In this article I will present to you the research that was conducted over the summer on rating systems of mobile applications across various domains. The goal of this project is to inventory and evaluate mobile app rating scales/frameworks that are currently being utilized and rate how effective they are in determining the quality of a given application. Additionally, there is relatively little attention on energy apps compared to the healthcare; thus, as a next step we will explore how to apply the most rigorous evaluation frameworks to energy apps.

**Literature Review**

The focus of the research done in this project sought to analyze mobile app rating scales and frameworks in addition to answering the following questions:

1) **What factors and attributes are used in mobile app rating scales?**
2) **Are these rating systems effective in determining the overall quality of a given mobile application?**
3) **How can we improve mobile app rating scales for future use in the energy domain?**

To gain an idea of how to approach these three questions we utilized the Google Scholar and ScienceDirect databases. The analysis of literature began with three primary articles and expanded to others after a forward/backwards citation search, in addition to an expanded search discussed in the methods section below.

The first primary article that was assessed to establish the foundation of this project was Gameful Experience in Gamification: Construction and Validation of a Gameful Experience Scale [GAMEX] by Rene Eppmann et al. (2018). This article clearly defined gamification as a technique, used most often in mobile applications or serious games, that helped guide the consumer to participate in a desired set of behaviors. It also helped to guide our research to explore questions that inquire about the effectiveness of gamification and what a “good” mobile app rating scale needs. The GAMEX scale is designed to help improve gamified applications in various domains. It evaluates the app design and marketability, and ensures that the gamification aspect of the app is up to par. This scale in particular has a focus on gameful experience. Another rating scale that was analyzed was MARS (Mobile App Rating Scale) (ref). This scale is outlined in Mobile App Rating Scale: A New Tool for Assessing the Quality of Health Mobile Apps (2015) and Development and Validation of the User Version of the Mobile Application Rating Scale (uMARS) (2016). Both articles produced by Stoyanov et al3 are foundational pieces of literature. The MARS system specifically targets mobile applications in the field of healthcare. MARS tests applications for functionality, engagement, aesthetics, and quality of information, all the ingredients that one would need to make a “good app”. This system was designed solely to
ensure that mobile applications are being tested for their quality as consumers are using them for important tasks such as keeping up with their health and medical needs.

These 3 articles helped to answer the first two questions of why the ratings scales are important and their effectiveness. The sources specifically detailed what mobile app rating scales include, defined gamification, and inquired about improvements that could be made to rating systems. Additionally, these sources provided guidelines for our methodological approach. An additional source that aided in creating the methods of this work was The PRISMA Statement for Reporting Systematic Reviews and Meta-Analyses of Studies That Evaluate Health Care Interventions: Explanation and Elaboration by Alessando Liberati et al. (2009). A PRISMA statement is a flow diagram that sorts information gathered in each stage of a systematic review. The purpose of this is to “ensure the transparent and complete reporting of systematic reviews and meta-analyses.” (Liberati). The PRISMA statement consists of a checklist and diagram with 4 phases (Identification, Screening, Eligibility, Included). From this we were able to create a PRISMA statement that fit our needs and outline the searches that were executed in a uniform and transparent manner. We modified the checklist to what is now the inclusion/exclusion criteria (see Methods) and kept the 4 original phases. This PRISMA statement was crucial to outlining our methods and ensuring that they were clear and repeatable.

In addition to reading articles that focused primarily on rating scales, we accessed articles that focused on gamification and the theory behind it. Gamification: What It Is and Why It Matters to Digital Health Behavior Change Developers by Brian Cugelman explains that gamification can be an important tool in behavioral change. His research states that gamification works because it is very similar to principles in psychological or health behavioral change techniques, they are persuasive. “…technology is only persuasive when it employs specific behavior change ingredients, as one of the key principles of evidence based behavioral medicine … persuasive ingredients are the factors that exert persuasive force on people, encouraging them to shift their beliefs, attitudes, and actions.”(Cugelman). Cugelman employs principals used in healthcare to explain how gamification will be of great use in the mobile app industry. This was a great article because it not only detailed how gamification works and is effective but also why it is able to be successful. On the opposite end Cugelman expounds the shortcomings that are attached to gamification. With this information it allowed us to see what criteria would be effective in creating a rating scale that weeds out the poorer gamified applications from those that are richer in quality and have greater potential to influence behavioral change.

Methods

The purpose of the research that is currently being conducted is to establish an evaluation system for mobile apps in the energy domain, utilizing the existing literature across domains. This evaluation system or framework should provide a systematic process for rating the quality of mobile apps related to energy and serve as a guide to improve effectiveness of these apps. The methods that are outlined in this section are based on the works of Eppmann et al (2018), Stoyanov et al (2015), and Stoyanov et al (2016). A forward and backward citation was performed for these three sources, providing twelve original articles. This was done to develop keyword search terms with minimal researcher bias. The inclusion/exclusion criteria were then applied to the list of search terms, removing duplicates, pluralized terms, terms not relevant to the project, and terms that were too general to provide meaningful results. A literature search was performed to select articles relevant to mobile application evaluation. These articles were
gathered through a web search using keyword combinations including mobile app, evaluation, quality (keywords which were gathered from the 12 articles) (Table 2). The search for literature was conducted in the database ScienceDirect and a set of inclusion/exclusion criteria were organized to remove articles that were not relevant, 90 articles were identified (included in appendix). Articles that were duplicates, previously cited, or did not fit the inclusion criteria were all removed. The inclusion criteria for the articles of interest required that: 1) the article describes a scale, assessment, evaluation, or framework method for apps, serious games or gamification; 2) the article reviews scales, assessment, evaluation, or framework method for apps, serious games or gamification; and 3) the article applies a scale that we have not yet seen or analyzed. All articles that were either a duplicate, not written in or translated into English, or were an application of a scale, assessment, evaluation, or framework method for mobile apps were removed. A detailed outline of this process is presented in our PRISMA statement (Figure 1), this provides a thorough breakdown of how all searches were conducted.

Table 1: Applicable Search Terms

<table>
<thead>
<tr>
<th>Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>app trustworthiness</td>
</tr>
<tr>
<td>App(s)</td>
</tr>
<tr>
<td>Behaviour change techniques</td>
</tr>
<tr>
<td>Customer engagement</td>
</tr>
<tr>
<td>Digital Health</td>
</tr>
<tr>
<td>e-health</td>
</tr>
<tr>
<td>engagement</td>
</tr>
<tr>
<td>entertaining games</td>
</tr>
<tr>
<td>evaluation</td>
</tr>
<tr>
<td>framework</td>
</tr>
<tr>
<td>Game experience</td>
</tr>
<tr>
<td>Gamification</td>
</tr>
<tr>
<td>Gamified service(s)</td>
</tr>
<tr>
<td>Mobile apps</td>
</tr>
<tr>
<td>mobile computing</td>
</tr>
<tr>
<td>Mobile health</td>
</tr>
<tr>
<td>mhealth</td>
</tr>
<tr>
<td>Motivational experiences</td>
</tr>
<tr>
<td>outcomes</td>
</tr>
<tr>
<td>perceived value</td>
</tr>
<tr>
<td>phone usability</td>
</tr>
<tr>
<td>Reviews</td>
</tr>
<tr>
<td>scale development</td>
</tr>
<tr>
<td>Self-determination theory</td>
</tr>
<tr>
<td>smartphone apps</td>
</tr>
<tr>
<td>social media</td>
</tr>
<tr>
<td>trusted computing</td>
</tr>
<tr>
<td>trustworthiness assessment</td>
</tr>
<tr>
<td>model</td>
</tr>
</tbody>
</table>
Terms

User experience

Note: Search terms gathered from the original 12 articles selected in the forward and backwards citations of Eppman et al. (2018), Stoyanov et al. (2015), and Stoyanov et al. (2016). This is the final list of search terms after all exclusionary items were removed (see Figure 1). This data was used to generate an additional search that focused on identifying more relevant articles that contained evaluations/reviews/frameworks of mobile apps and mobile app rating systems.

Table 2: ScienceDirect Search Results

<table>
<thead>
<tr>
<th>Keyword Combo</th>
<th># of Results</th>
<th># of Relevant articles</th>
<th># of Relevant articles in first 100</th>
<th>Total # of articles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gamification AND (evaluation OR framework OR review)</td>
<td>1290</td>
<td>53</td>
<td>53</td>
<td>53</td>
</tr>
<tr>
<td>gamification AND &quot;scale development&quot;</td>
<td>13</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>gamification AND (trustworthiness assessment model)</td>
<td>51</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>&quot;mobile app&quot; AND (evaluation OR framework OR review)</td>
<td>3429</td>
<td>11</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>&quot;mobile app&quot; AND &quot;scale development&quot;</td>
<td>24</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>&quot;mobile app&quot; AND (trustworthiness assessment model)</td>
<td>143</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>&quot;mobile health&quot; AND (evaluation OR framework OR review)</td>
<td>1913</td>
<td>13</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>&quot;mobile health&quot; AND &quot;scale development&quot;</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>&quot;mobile health&quot; AND (trustworthiness assessment model)</td>
<td>55</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>smartphone app AND (evaluation OR framework OR review)</td>
<td>1814</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>&quot;smartphone app&quot; AND &quot;scale development&quot;</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>&quot;smartphone app&quot; AND &quot;trustworthiness assessment model&quot;</td>
<td>54</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Total articles 102
Total number of articles retrieved 8804
Number of duplicates 12
Total remaining articles 90
Note: List of search terms and results generated in ScienceDirect that produced our 90 articles of interest. A complete list of the articles found is listed in the appendix section.

Figure 1. PRISMA statement tailored to the inclusion and exclusion criteria of the project. Provides a detailed outline of how the final articles were gathered and how the inclusion criteria were applied to limit the number of overall results. The result is a select number of articles that are relevant to helping our research create a new framework to grade mobile app rating scales.
Data/Findings/Analysis

At this point in the project we have gathered a total of 90 articles and tested the inclusion and exclusion criteria that we predicted would be the most effective in finding quality applications. The criteria were tested on 5 articles (chosen at random) of the 90 retrieved from ScienceDirect. The articles that were a part of the sample were categorized by domain and year, then the abstract was analyzed to see if it qualified. Of the 5 articles only 2 of them met the inclusion criteria while the other 3 failed to. We used this data to confirm that the inclusion/exclusion criteria are a viable way to find articles of interest.

Figure 2. This graph displays the 90 articles that were selected from the second ScienceDirect search. They are categorized by the domain in which the article belongs and separated by the year of publication.

Table 3: Test of inclusion/exclusion criteria on articles from ScienceDirect search

<table>
<thead>
<tr>
<th>Title &amp; Author</th>
<th>Year of Publication</th>
<th>Domain</th>
<th>Does it fit the established criteria? (Y/N)</th>
<th>If yes, what is the framework that was used?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis of Gamification Models in Education Using MDA Framework (Kusuma et al)</td>
<td>2018</td>
<td>Education</td>
<td>Y</td>
<td>MDA (Mechanics, Dynamics, &amp; Aesthetics)</td>
</tr>
<tr>
<td>How to design gamification? A method for engineering gamified software (Morschheuser et al)</td>
<td>2018</td>
<td>Games/Tech</td>
<td>N</td>
<td>N/A</td>
</tr>
<tr>
<td>Title &amp; Author</td>
<td>Year of Publication</td>
<td>Domain</td>
<td>Does it fit the established criteria? (Y/N)</td>
<td>If yes, what is the framework that was used?</td>
</tr>
<tr>
<td>------------------------------------------------------------------------------</td>
<td>---------------------</td>
<td>-------------------------</td>
<td>---------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td><em>Hook vs. hope: How to enhance customer engagement through gamification</em> (Eisingerich et al)</td>
<td>2019</td>
<td>Business/Marketing</td>
<td>N</td>
<td>N/A</td>
</tr>
<tr>
<td><em>Perspectives on usability guidelines for smartphone applications: An empirical investigation and systematic literature review</em> (Ahmad et al)</td>
<td>2018</td>
<td>Games/Tech</td>
<td>N</td>
<td>N/A</td>
</tr>
<tr>
<td><em>Assessment of the Health IT Usability Evaluation Model (Health-ITUEM) for evaluating mobile health (mHealth) technology</em> (Brown et al)</td>
<td>2013</td>
<td>Health</td>
<td>Y</td>
<td>ITUEM (IT Usability Evaluation Model)</td>
</tr>
</tbody>
</table>

*Note: 5 articles used to test the criteria established.*

**Discussions**

At this stage in the research we have successfully developed a reliable set of criteria to help retrieve articles relevant to our area of focus. The first test of the criteria (see Table 3) provided two assessment models the MDA (Mechanics, Dynamics, & Aesthetics) and ITUEM (IT Usability Evaluation Model). The MDA framework scales 3 aspects of a mobile application, the mechanics, dynamics, and aesthetics. It rates how effective a variation in each of the 3 aspects is in creating a successful application that helps the user reach the desired goal. The ITUEM, however, was an assessment that looked at all the aspects of an application in relation to the ease of use. This framework aimed to scale how “usable” an app was as a mode of rating the apps’ overall quality, considering that this component is vital to the success of a mobile application. These two frameworks helped us to consider criteria that should be evaluated to rate the overall quality of an app.

Our current selection criteria, detailed in the PRISMA statement, resulted in 90 articles for full review from a single database. Our future goals include making the criteria even more selective to produce more targeted results with fewer articles that are not relevant to our goals. Additionally, all of the articles were collected from only one database, ScienceDirect. To ensure that we are considering all possible resources we plan to expand to other databases to reduce any bias.

Future plans following closing up these gaps in our corpus development are to compile a solid list of articles that either contained evaluations/reviews/frameworks of mobile apps and mobile app rating systems or a new framework (that was not previously analyzed). After this we will be able to critically analyze the frameworks thoroughly and evaluate the metrics and their applicability to the energy domain in order to create a comprehensive framework for evaluating apps in the energy domain.
References


Footnotes

1Gamification is the application of typical elements of game playing (e.g. point scoring, competition, badges, etc.) to other areas of activity outside of regular gaming such as healthcare, energy, and education to name a few. Typically, this technique is used to encourage engagement with a product, service, or to urge the user to take on a desired set of behaviors.

2Mobile applications and serious games include phone applications that can be accessed from the Apple/Google Play store, computer games, and standard video games/games played on a console (i.e. PlayStation, Xbox, Nintendo, etc.). These games have rewards/point systems and have the capability of being competitive. They are typically created for the purpose of entertainment but can be used to educate as well.

3It is important to note that the key differences between Stoyanov et al 2015 and 2016 is that the 2016 version uses uMARS while the 2015 version uses MARS. uMARS is the user version of the MARS assessment while MARS is not.

Appendix

Note: List of 90 articles gathered from ScienceDirect search using keywords from Table 2. Includes author(s), publication year, title of work, and doi.


How Do Black College Students Select their Academic Majors? Identifying Patterns of Change and Factors of Influence

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Black and African American college students face systematic racial barriers that contribute to disparities in college retention and graduation rates. Previous research shows that disparities in academic major selection persist after college and ultimately affect socioeconomic mobility. However, very little is known about how Black students navigate the process of academic major selections. The current study examined how and why Black students choose an academic major in the first two years of college. We analyzed four waves of data from Black college students (N = 18) who responded to an open-ended survey question describing the pathway they took to their current academic major over the course of their freshman to sophomore year. Results showed that 44.4% of students changed their major, while 50% remained in the same major (5.6% were undeclared). Through open-coding we identified four pathways of academic major selections: (a) Congruent; (b) Adaptation; (c) Constrained; (d) Exploration, and noted the internal and external factors that influenced these pathways overtime. The majority of participants either stayed or deviated from their academic major due to external factors (e.g., financial restraint, parental advice, etc.), in comparison to internal factors (e.g. skills, abilities, personal experiences). These data indicate that Black students are negotiating a variety of influences that shape their academic major selection process.
Introduction

We live in a society that is conditioned to view Whiteness as the standard, placing other racial and ethnic groups beneath it; socially, economically, and politically. This hierarchy works to disenfranchise minority groups on many levels, including academically. Segregation is the legal system set in place to promote inequality, and allowed school systems in areas where Black people lived to legally implement laws that limited academic opportunities for people of color. Although this structure was put into place decades ago, Black students are still dealing with the ramifications of its impact today as they receive fewer resources and less exposure to higher education.

Research has shown that Black students lack the resources needed to academically achieve in college as only 57% have access to the full range of math and science courses necessary for college readiness, in comparison to 81% of Asian students and 71% of White students (Bridges, 2018). Not only are these disparities seen within the primary levels of education, but in higher education as well. A study by The Education Trust, reveals that graduation rate for Black students falls far behind their peers of other races and ethnic groups at a 40.9% completion rate (Nicholas & Bell, 2017). Data from the National Center for Education Statistics also shows that nearly 41% of first-time, full-time Black students who enrolled at four-year institutions in the fall of 2008 earned a degree within six years. This was the lowest rate among all racial and ethnic groups, approximately 22% points below the graduation rate for White students.” (Nicholas & Bell, 2017). These racial disparities in enrollment, graduation, and retention rates prevent Black students from obtaining success.

Previous research has emphasized the differences in academic major selection from a racial and ethnic stance by viewing the disparities across all demographic groups, as well as the exploring gender inequalities that exist between academic majors. However, there is a lack of research that explores the how and why Black college students select an academic major. If we understand the ways in which Black students navigate the academic major selection process, we could possibly support their retention and graduation rates. The current research focuses on the first two years of the students’ college experiences, which are vital for setting up the student’s future trajectory, to describe how Black students select their academic majors, and the factors that influence their decision processes over the first two years of college.

Literature Review

The Social Hierarchy of Academic Inequality

Minority’s racial and ethnic educational and income markers continue to rank low in society’s social hierarchy, due to historical events that has set the stage for their trajectory. Although, prejudice-based discriminatory policies such as segregation, redlining, Jim Crow laws, and pay gaps are no longer legal; they continue to restrict the social and economic capital of Black and Latinx communities (Cameron & Heckman, 2001). These policies affect the lives of families today on many levels: education matters being the most prevalent. By limiting choice and control, these discriminatory policies placed minorities at the bottom of the social hierarchy, and pushed Blacks to take on identities that marked them as being individuals of low ability and low will (Oyserman & Lewis, 2017).
Evidence has shown that minority children are more likely to come from a low-income family whose members have only achieved low levels of education, which places them at the bottom of the social hierarchy (Oyserman & Lewis, 2017). Multiple factors such as poverty levels and low education, put these students at risk for higher dropout rates, which contrasts the better educational outcomes for students whose families reside at the top of the hierarchy. Furthermore, these high rankings are associated with better test performance and a higher likelihood of completing high school and college (Oyserman & Lewis, 2017). Additionally, some analyses have found that racial minority youth would be more likely to enroll in four-year colleges than their White peers if they came from families with the same demographics as them: family income, parental level of education, location of residence, and etc. (Cameron & Heckman, 2001; Oyserman & Lewis, 2017), which underscores the notion that Black students need community in order to work towards academic success.

Most importantly, Oyserman and Lewis’s research showed that the gap between aspiration and attainment is associated with one’s placement in the social hierarchy; which is defined by the geographic location and their family circumstance. For instance, black students are striving to reach success, however due to racial disparities they are unable to attain long term academic outcomes which can be seen in their college graduation, enrollment, and retention rates, in turn impacting the way they navigate college and select their academic majors within higher education. In sum, racial disparities in academic achievement continue to plague minority students due to the lack of resources, opportunities, and exposure to higher education during primary school, however these disparities do not just exist in high school but follow students into their college experience as research finds low graduation and retention rates amongst Black students.

Disparities in College Academic Majors

Research shows that disparities also exist in academic major selections. For example, there are large differences in the average earnings of people who select different academic majors in college. Recent studies show the economic differences that exist within STEM verses non-STEM majors (Carnevale, Stroplh & Melton, 2011). The average earnings of individuals who choose STEM (science, technology, engineering, and mathematics) are associated with high earnings, while those who select majors in counseling psychology, social work, or education are usually associated with low earnings. Furthermore, this report found that the annual earnings of full time, full year workers in petroleum engineering make about $120,000, whereas the comparable figure for those who majored in counseling psychology made about $29,000 (Carnevale, Stroplh, & Melton, 2011). Although students may not be fully aware of these economic disparities that occur within their academic major selections, it is still a key factor that may impact their future trajectory.

College majors affect the outcomes of people across different racial groups as well. Racial disparities within demographic groups show how Blacks and Latinx students are more likely to earn lower wages than their White and Asian peers (McCall, 2001). They also find that Black students, in comparison to Whites, are highly underrepresented in natural and technical sciences. However, the National Center of Education Statistics counteracted this point, by emphasizing that African Americans, Latinos, Asians, and Whites are equally likely to declare high paying STEM majors, as all students aspire to attend college (Chen, 2009). However, differences were observed in whether or not the students remained in STEM. STEM bachelor
completion rates were higher among White and Asian students, students with at least one parent who had a four-year college degree, and individuals who had a high level of academic preparation for postsecondary school (Chen, 2009). Although, the entry rate for STEM majors did not measure significant differences, racial variety could be seen in completion rates of STEM majors. Research also shows that the racial and ethnic gaps especially those in math and science expertise are projected to take 3 to 4 years generations to close (Beck & Muschkin, 2012)

**Identity-Based Motivation and Academic Majors**

Selecting a major is also related to the developmental task of identity development—figuring who are and what you want to be (Erikson, 1968; Stephen, Fraser, & Marcia, 1992). During the late adolescent years (18-22) the task of resolving one’s identity is an important anchor and guide for future life choices and outcomes (Oyserman, Elmore, & Smith, 2012). Much of the research on the identity formation of Black college students has pointed to the importance of racial-ethnic identity. Research studies have found that students generally report a higher sense of belonging at schools in which their racial and ethnic group dominates the space (Johnson, Crosnoe, & Elder, 2001). Although, the study was conducted on high school students, it speaks to the intricate role of their racial and ethnic identity as viewing themselves from this lens allows students to interpret and make meaning of their experiences socially and individually. Furthermore, it also allows them to give meaning to historical and current barriers they have faced within their racial-ethnic groups and consolidate self-relevant knowledge about their personal effort as it pertains to themselves and other in group members (Oyserman, 2007).

Oyserman developed a theory to explain how macro-level and immediate social context (e.g. poverty, education, race-ethnicity, and stigmas) influence educational outcomes through effects of identity-based motivation (Oyserman & Lewis, 2017). Previous research has predicted that social context ultimately impacts the academic outcomes of students, however this model provides a deep analysis of the process by describing the features of macro level and immediate social context and how they cue identity-based motivation, which directly influence academic outcomes. The process allows students to make sense of their current and future identities by pushing them to ask questions about who they are, strategizing, and how they interpret experiences in school (Oyserman & Lewis, 2017). This identity-based motivation directly impacts academic outcomes by disrupting the effect of stigmas. This process is vital for the educational outcomes of Black students. In order for them to mobilize they must work to eliminate the stereotypes and figure out ways to effectively navigate the system.

Using identification-based motivation as a framework to explore career choice and interest, we sought to understand the academic success of Black college students through examination of their major pathways. Black students are not only faced with issues that prevent them from succeeding but they are also negotiating ways to understand their identity in order to gain better academic outcomes and eliminate racial disparities. Furthermore, this theory speaks to the issue of how a major and clarity about one’s interest can support graduation and reduce these disparities in academic selection.

**Current Study**

The purpose of the current study is to examine the academic major pathways of Black college students, and to understand the factors that influence their decision-making processes.
My research examined two primary questions: a) How do Black students select their academic majors in the first two years of college? b) What are the primary decision-making factors that explain why they make these decisions?  

**Methods**

**Participants**

Participants in this study included 18 self-identified Black students in the U.S. drawn from a larger longitudinal study on ethnicity and college attainment. The participants’ average age was 18.15 ($SD = 1.07$). The sample included 50% Black immigrants who were born outside of America (Afro-Caribbean, Afro-Latino, and African) and 50% who were native born Black students.

**Procedures**

The participants were recruited as part of a college orientation event for incoming students of color at a large Midwestern university in the United States with a student population of 51,147. The survey was administered as part of the orientation activities. Participants were escorted to computer labs on campus and completed an online survey. The survey included numerous rating-scale and open-ended questions, and took approximately 30-45 minutes to complete.

**Measures**

The primary measure of interest for this analysis was an open-ended narrative prompt that asked students about their academic major choices at each wave of data collection. The narrative prompt stated:

*Please write a summary of the path you took to your current major (e.g., what you wanted to major in when you were younger, whether you changed your mind at any point, etc.). Be as detailed as possible, including reasons for why you made your decisions, and whether you talked to anyone about your decisions. It is okay if you have not decided on a major yet, just write about the different career options you have considered or dreamed about."

Students responded to this prompt during a computer-based survey and typed their narrative in an open text box. We analyzed students’ verbatim narratives.

**Narrative Coding**

During the analysis process, we conducted four different phases of coding. We began by memoing all of the students’ responses to the open-ended question. In the 2\textsuperscript{nd} Phase, we began to note salient themes that were occurring across time in the student’s major selections, in particular whether or not students changed their major across the four waves of data, and how students noted their interest or curiosity in the subject or topic. In the 3\textsuperscript{rd} Phase, we noted a developing coding pattern for the variety of ways that students either remained stable in their major or deviated from it in correlation with their interest. We created a cross tabulation of “change/stability” and “interest” to categorize students’ responses across the waves of data.

The final phase of coding allowed us to explore the decision-making processes that contributed to the students’ major selections. Initially, we color coded these themes and labeled them as internal and external influences. External influences consisted of elements outside of the
self that worked to either encourage or restrict the students’ major pathway; while internal factors were defined as influences within the self that encouraged or restrict their decision-making processes. Sub-codes were developed for each of these two factors. External included elements such as programs, organizations, interpersonal and social influences (e.g. peers, advisors, teachers, etc.), high school experiences, college coursework, and college restrictions. Internal influences consisted of sub-codes such as skills, abilities, helping humanity, resilience, faith, and personal experiences. We wanted to know why they selected the majors over these four waves. Ultimately, we used open coding to measure the students’ major pathways from their freshman to sophomore year by analyzing how they selected their majors through an evaluation of their interest and major stability and deviation over time and explored the factors that contributed to their decisions: external and internal.

Results

This results from the 3rd phase of coding yielded four pathways that described the stability and change in students’ academic major interest and selections across the first two years of college. (a) Congruence—Individuals who had the same interest and same major; (b) Adaptation—students who came into college with a specific interest in mind, which allowed them to adapt their major, which left room for them to change it; (c) Exploration—students that simultaneously changed their major and interest; (d) Constrained—students who changed their interest, but remained in the same.

In the following case studies, I will illustrate through in-depth analysis of how I coded for each of the four categories across four waves. Although, all of the waves were not included for each participant, I will break down the coding process.

Case Study 1: Constrained

In the example of Constrained, Participant 186 stated in Wave 1:

“I wanted to be a vet when I was younger but as a grew older my passions started to change. I have always liked the sciences but my passion for animals decreased as I got older. I never wanted to be a doctor but I am leaning toward professional school in dentistry or pharmacy. Entering these professional schools helped lead me towards the majors I am considering.”

In reflection to his first response, I noted the key elaboration of the students’ interest of wanting to be doctor and enter dentistry and pharmacy school. This student did not have a second wave, but in the third wave can see that this student was restricted to their major due to financial constraints:

“I did plan to leave the CLA for my major but decided against it when I found out I would lose a major scholarship if I did. I do feel that I was forced into my major by financial issues and the CLA’s lack of science majors. My major will still be able to help me with my future career plans and that is why I am okay with it.”

I noted the usage of the word “force” to truly understand the pressure on this student to remain in the same major, despite of desire to switch. The fourth wave stated:

“I knew I wanted to be a dentist entering the university. Therefore I picked this major because it fill many of the prerequisites for dental school. I would have wanted to be a Genetics major but I had a scholarship through the College of Liberal Arts that prevented
me from switching colleges. Looking back at it I'm not as bothered since my major did not have a great influence on my goals.”

This student was categorized as Constrained due to their consistent interest in dentistry and pharmacy school, meaning that the interest stayed the same, however because of financial constraints they were unable to change majors. I also noted their key mentioning of still planning to reach their end goal of professional school despite college restrictions.

Case Study 2: Exploration

Participant 186, coded as exploration, stated:

“I originally entered the university with the intentions of majoring in Theater Arts. Over the course of my freshman year, I took a few courses in the theater department and I soon fell in love with the major. My parents resented me majoring in theater arts even though they acknowledged the skills and potential I had in the major. Regardless of such, they highly encouraged me to switch due to the difficulties of finding a job after graduating. So with a lot of thought, I switched my major in journalism because I truly do have a passion for public speaking and I have strong interpersonal communication skills. I at first resented switching my major because I was getting a little bit of a late start with taking journalism courses. I added Afro studies to my major because I took an Afro course during my freshman year and fell in love with the department and the course that it offers. I set out to double major in Afro studies and journalism but due to trying to complete all of my classes in four years, I switched my major in Afro studies to a minor.”

The student continuously switches majors due to the internal and external factors of personal interest, parental influences, coursework, and skill and abilities. I noted the constraints of the student to switch majors due to the parent’s statement of them not finding a job. This limited the student to revert back to journalism which was the first major in mind. By the end of wave, they had changed their major, as well as their interest.

Case Study 3: Adaptation

This example was derived from Participant 197, which will exemplify Adaptation. In the first wave Participant 197 stated: “I have always wanted to major in Math and Science and I have questioned what I wanted to study but I always enjoyed math so that’s why I decided to major in Civil Engineering.” During the memoing process, I noted the key mentioning of their interest in Civil Engineering, following their passion for math and science courses, which was color coded as an internal factor. The second wave stated:

“as of this point I think I want to major in Civil Engineering because every since I was a kid, I’ve enjoyed working with math and I think math mixed with my joy working with hands on projects civil engineering would be a perfect field.”

The student continuous to mention their love for math and major selection of Civil Engineering in this section. The Last Wave stated:
“When I was in high school I always wanted to be an engineer and it was the same freshman year but after taking a few courses I changed my ways of thinking. Then I switched to Environmental Science. and now I'm looking at Informational technology.”

By this wave, you can see the student though process and the external factors of led to their shift of majors. Their interest remained stable, however due to rigorous coursework they deviate to another major.

**Case Study 4: Congruent**

This case will encompass an individual who remained stable through interest and major selection in all waves, which was categorized as Congruent. In the first wave, Participant 455 stated:

“when I was young, I had the dream of becoming an aeronautic engineer or an astronaut although I didn't have the bearest minimum idea of what it entailed to be one. As I grew older, I realized that I selected the major probably because I liked the way the names sounded. I asked a couple of elderly people about the future profession issue and they listed quite a lot of advantages as well as disadvantages of the pre-intended major. The disadvantages however took the larger part of it, so I decided to go into Mechanical Engineering as there were tonnes of advantages over the disadvantages.”

I initially, noted how the student goes about using external factors such as social influences to weigh the pros and cons of his interest, which led them to Mechanical Engineering. In the third wave, they stated:

“As a little kid growing up, I've always loved to dismantle machinery and objects just to see how they functioned and how they were to put together. This intriguing passion, in addition for my flare for mathematics and the sciences made me most certain that Mechanical Engineering is the major for me and what I would love to study in college. What better University than the University of Minnesota is there to be groomed to perfection in this field? None.”

In this wave the student elaborates on their skills that led them to their current majors. The student’s interest in math and dismantling objects were coded for internal factors. We can see the continual major selection of Engineering, which was also mentioned in Wave 1. The last wave stated:

“I am more science, to be more specific engineering-oriented. I had difficulties trying to pick out which of the engineering programs I wanted to indulge in. But thinking back to the early years of my childhood, I was notoriously known for dismantling items and a majority of the time not being able to put it back together and I most of the time got in trouble for that. I was driven by the functionality of this devices and I wanted to figure out how they actually worked; the thinking behind it, the electrical and also mechanical aspect of it. Mechanical Engineering is a field of engineering which touches almost every side of Engineering; from Electrical to Computer, Chemical, Material Science and the variety of them. That's how I came about selecting my current major.”
By this point, their narrative as become a lot more descriptive as they speak on how they’ve always had a desire to major in Engineering, which was broadened when they considered their childhood passions and skills of dismantling objects. This individual utilized internal factors within themselves to remain consistent in interest and major.

The results for our findings can be seen in the table below, which states that Congruence included the majority of the participants with 8 in total, following Adaptation with 7, Constrained with 1, and Exploration with 1. We found that 50% of the students were stable in their interest and major across time, while 44% changed their major in response to their interest. The last 5.6% was undeclared. Amongst all of the categories, congruence had the highest percentage, which can be seen in the table below.

Table 1

<table>
<thead>
<tr>
<th>Same Interest</th>
<th>Change interests</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Same Major</strong></td>
<td></td>
</tr>
<tr>
<td>Congruent n=8</td>
<td>Constrained: n=1</td>
</tr>
<tr>
<td><strong>Change Major</strong></td>
<td></td>
</tr>
<tr>
<td>Adaptation: n=7</td>
<td>Exploration n=1</td>
</tr>
</tbody>
</table>

In the 4th Phase of, we find that external factors are the greatest contributing factors to Black students’ major selection. Specifically, students most frequently mentioned interpersonal and social influences being the highest subcategory, Followed by coursework and high school experiences.

Figure 1

Although measures did not show significant variations in the internal influences; helping humanity, skills/abilities, and personal experiences were the greatest influences in these for these student major selections.
Our findings also show overlaps that exist between stability and the change of major selection in relation to external and internal influences. These results state that 50% of participants remained or deviated from their major due to external factors, while 11% were influenced by internal factors. These findings show the process of how Black students were selecting majority external factors in order to consolidate their majors. The process significantly speaks to Black students understanding of higher education, as the findings suggest that they are influenced by rigorous coursework and high school experiences. These individuals are striving to obtain academic success, yet the lack of preparation in secondary school has put limitations on their academic outcomes. Interestingly, the data showed that 72% of these Black students were STEM majors, which is contrary to previous research. Although, external factors show lack of resources these individuals are still striving to obtain academic success.

Our analysis also examined the overlap of student’s major selections and the influences that contributed to this process. Our findings show that majority of the categories were influences by external factors, with Adaptation being the category with the highest number of external factors. Students in this category had the same interest over the four waves, however grew into their majors.
The purpose of this analysis was to understand how Black students selected their academic majors and explore the contributing factors that influenced their decisions. The coding process looked into how Black college students described their selection of an academic major over the first two years of college experience, which revealed notable variability. First, we found that half of the students changed their major, and interest was also relevant to the stability or change in major selection. Specifically, some students held the same interest but had to change their major due to external factors. In fact, external factors surfaced as a primary influence on the student’s decision-making processes. Furthermore, interpersonal and social influences were the greatest which shows the importance of community in Black student’s lives, especially during their young adulthood. Often times, Black individuals feel the need to walk in solidarity and reject their identity by dissociating from the majority due to the historical events that took place and the negative stereotypes that are associated with their racial and ethnic identity. However, our data has shown that despite these ramifications, the community that these students reside in is efficient enough to positively influence their decision-making processes.

In addition, preparation in high school coursework was the second highest external factor which exemplifies the data that Black students are not likely receiving access to resources prior to college and are not being academically prepared for rigorous college work. Most individuals who were categorized in this area, made statements regarding their lack of skills needed to fully grasp the science-based courses, which speaks to the problem regarding Black students’ lack of access to the full range of math and science courses necessary for college readiness.

Interestingly, contrary to previous research and data-trends about racial disparities that exist in STEM majors, the Black students in our study were choosing STEM related majors in their first two years of college, which raises the question of whether or not large numbers of Black students opt out of STEM fields later in their college trajectories.

Major selections are an important key that is hardly researched in Black students, however if we can understand how they go about selecting their majors and the way they
navigate college, we can reduce the disparities that plague the community and increase Black students’ retention, enrollment, and graduation rates.

**Limitations**

There were several limitations in the current study. For example, the university that this study was conducted in, may have put restrictions on specific majors, preventing students from selecting their preferred majors as some have ability requirements such as a minimum 3.0 GPA and a maximum number of course hours needed to enroll. Furthermore, the prerequisites for each college differs depending on the program as each major is housed within several different colleges. It is also the case that some participants may not be aware of all of the possible majors given the restricted curriculum offered in secondary school because of the limited counseling services and restricted access to resources and knowledge leading to student’s lack of exposure to non-popular majors. Additionally, many of these high schools may not prepare students for college because the curriculum differs academically as well. Another limitation that should be considered is the fact that this study will be conducted on Black students who attend a predominately white institution, which can alter the conclusion of the results because their environment and experiences may differ from other Black students who attend a historically Black college.
References


Mental Health of Undocumented, Latinx Students

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INTRODUCTION

The Department of Homeland Security (DHS) defines the unauthorized/undocumented population as “all foreign-born non-citizens who are not legal residents” (Estimates of the Unauthorized Immigrant Population Residing in the United States, 2017). As of 2019, there are approximately 11.3 million undocumented immigrants residing in the United States with 73% being of Latin American descent (Profile of the Unauthorized Population—US, n.d.). Out of those, about 1.6 million are in the college-aged years ranging from 18-24. Approximately 65,000 undocumented, high school students graduate every year, but only 20% will enroll in any form of post-secondary education (Bjorklund, 2018; Gonzales, 2016; Hsin & Ortega, 2017). An even smaller percentage will graduate with a bachelor’s degree and current estimates show only 15% of the undocumented adult population held a bachelor’s, professional, or graduate degree (Profile of the Unauthorized Population—US, n.d.). Current exclusionary barriers such as financial aid restrictions that prevent undocumented students from obtaining higher education are often state-sanctioned and institutional wide policies that restrict access, admission, and opportunities. Within these contexts, universities can become unsafe spaces of exclusion which can further create psychological harm and distress to undocumented, Latinx students (Huber & Cueva, 2012). As such, the undocumented, Latinx student population can be vulnerable to psychological and social distress (R. G. Gonzales et al., 2013).

Much of the research regarding immigration status (eg., citizen, resident, undocumented) as a social determinant of mental health outcomes has largely focused on the adult and child populations. A smaller subset of research has focused on how these factors influence the mental health, psychosocial wellbeing, and educational attainment of adolescent populations. Even fewer studies have focused on the mental health of undocumented students pursuing post-secondary education at a 4-year institution. Often researchers have explored how non-traditional forms of counseling such as peer mentoring, familial support and communal engagement can be protective factors for the mental health outcomes of undocumented, Latinx youth. Additionally, much of literature regarding counseling for undocumented students primarily focuses on school children enrolled in the K-12 grade school levels. This review examines the existing literature regarding the protective factors for undocumented, Latinx students in higher education.

BACKGROUND

A. Historical and Legal Precedents

To have an accurate portrayal of the admission and inclusion of undocumented students in higher education, a review of the legal and historical precedents must begin earlier at the grade school level. In the landmark case of Plyler vs. Doe of 1982, the U.S. Supreme Court ruled it was unconstitutional for states to ban the entry, admission, and access to a free, public education for
undocumented students through the K-12 grade levels (AMI, 2016). In its verdict, the Court defended their ruling stating that denying undocumented students to education would also be “[denying] them the ability to live within the structure of our civic institutions, and foreclose any realistic possibility that they will contribute in even the smallest way to the progress of our Nation.” The civil suit was a response to discriminatory policies implemented by the state of Texas denying enrollment to and imposing fees upon undocumented children attending public elementary schools. Since its enactment, multiple state and municipal legislatures have attempted to overrule the Court’s decision to no avail. Plyler has established the inclusion of undocumented students in public schools as the educational attainment of undocumented youth (ages 3-17) has been successful as 92% are enrolled in primary education (MP1, 2016).

No such law exists at the federal level to ensure equal rights are afforded to undocumented students in post-secondary education making their enrollment a rarity in college campuses. Failing to institute federal-wide protections for undocumented individuals in higher education has opened the doors for punitive and restrictive policies that actively seek to curtail the admission of and aid to undocumented students. In 1996, the Personal Responsibility and Work Opportunity Reconciliation Act made undocumented immigrants ineligible to receive federal benefits including federal financial aid to support their education (Public Education for Immigrant Students, 2012). Soon afterwards, Section 505 of the Illegal Immigration Reform and Immigration Responsibility Act of 1996 prohibited undocumented immigrants from qualifying for in-state tuition rates at public universities. Three states (Alabama, Georgia, and South Carolina) have implemented even more stringent laws prohibiting the admission of undocumented students in public universities and repealing in-state resident tuition (ISRT) policies (Tuition Benefits for Immigrants, n.d.). Such laws have had drastic effects in the educational attainment of undocumented youth aged 18-24 as only 37% are enrolled in an educational institution (MPI, 2016). An even lower percentage of 15% hold a bachelor’s, professional, or graduate degree (PRC, 2016; MPI 2016). To circumvent these restrictions, twenty-one states have implemented protective in-state resident tuition (ISRT) policies that make undocumented students eligible for paying in-state tuition rates at public universities if they qualify for residency criteria (Rincon, 2008; Gonzales, 2016; Dickson, Gindling, & Kitchin, 2017). In 2001, Texas passed Senate Bill 1403 (SB1403) becoming the first state to allow undocumented students to pay in-state tuition if they qualified for state residency (Rincon, 2008). In doing so, students were also eligible to receive alternative sources of funding such as state financial aid (Rincon, 2008). Such policies have significantly increased the accessibility and completion of a higher education degree for undocumented youth particularly in the state of Texas where enrollment of undocumented, Latinx youth rose by 3.4% (Dickson, Gindling, & Kitchin, 2017). While such state-based policies have increased accessibility of higher education for undocumented, Latinx students, their enrollment across universities in the nation remains a small percentage in comparison to the total student body population (College Board, 2019).

Advocacy groups argue the necessity of implementing federal protections for undocumented students in post-secondary education. Others call for a comprehensive, immigration reform that can offer undocumented individuals a legal pathway to citizenship and part of the American Dream. In 2012, President Barack Obama passed the executive order Deferred Action for Childhood Arrivals (DACA) providing a work permit and temporary protection from deportation to those who met inclusion criteria (Gonzales, 2016; Martinez, 2014; Dickson, Gindling, & Kitchin, 2017). To be potentially eligible for the permit, applicants must have met some of the following such as arriving to the US prior to the age of 16, have resided in
the US for at least five years, have no past criminal convictions, and be currently attending school or be recent graduates (Consideration of Deferred Action for Childhood Arrivals (DACA), 2018). Since its inception, the program has afforded DACA status to nearly 800,000 individuals and there are currently about 690,000 DACA recipients as of 2019 (Key facts about ‘Dreamers’ enrolled in DACA | Pew Research Center, n.d.).

DACA was applauded as a step towards immigration reform, but researchers contest the efficacy amongst undocumented youth as it has had varied effects on their educational and mental health outcomes. In a study analyzing the effects of DACA, a differential analysis demonstrated that undocumented youth not currently enrolled in college where more likely to pursue employment opportunities due to the prospect of financial stability rather than enroll at a post-secondary institution (Dickson et al., 2017; Hsin & Ortega, 2017). Simultaneously, they theorized DACA offered protective benefits for undocumented youth currently enrolled in university as they could obtain a driver’s license without the fear of being detained and obtain an on-campus job to help finance their education (Dickson et al., 2017). They proposed that the ability of obtaining a work permit served as an incentive for undocumented students to complete their studies as they would be able to practice their profession.

Furthermore, there are mixed results when analyzing the impacts being a beneficiary of DACA has had on the mental health outcomes of undocumented, Latinx youth. Despite the afforded protection from deportation, DACA-recipient college students and graduates reported feelings of social distress, uncertainty about the future, and distrust of (R. Gonzales, 2016). In a separate study, students reported increasing feelings of limitation and disempowerment as they were unable to resolve issues surrounding illegality and the long-term implications of DACA remained unclear (Cha et al., 2019). Simultaneously, DACAmented, Latinx students reported feelings of hope and relief upon being granted DACA status as certain burdens were lifted and allowed them to navigate larger domains of society. A participant noted the importance obtaining a driver’s license had in improving their own mental health outcomes and helped them perform better in school (Cervantes et al., 2015). DACA has functioned as a temporary protected status afforded to a select demographic of the undocumented population. However, under the ambiguous sociopolitical climate and uncertainty of the future of DACA, it has failed to appease feelings of psychological distress amongst undocumented youth (R. Gonzales, 2016; R. G. Gonzales et al., 2014; Hsin & Ortega, 2017).

DACA has been rescinded under the current Trump administration, but several appeals by lower-level courts have maintained the protections alive (MPI, 2019). The ambiguous future of DACA places the livelihood of undocumented youth and their families at a vulnerable position susceptible to psychological harm (Abrego & Gonzales, 2010; Dickson, Gindling, & Kitchin, 2017; Gonzales, Suarez-Orosco, Dedios-Sanguineti, 2013; Siemmos et al., 2017). The sociopolitical context can also serve to accentuate the feelings of not belonging amongst undocumented, Latinx youth who may be out of place in their universities and in society-at-large (Gonzales, Suarez-Orosco, Dedios-Sanguineti, 2013; Perez, Cortes, Ramos, & Coronado, 2010). It is pivotal to contextualize the experiences of undocumented, Latinx students under the current sociopolitical context that fails to provide undocumented immigrants with an accessible path to citizenship.

B. The “1.5 Generation”

Approximately 86% of undocumented, Latinx students in higher education institutions came as childhood arrivals (prior to the age of 12) meaning they’ve lived most of their
developmental years raised in the US. They have been named the “1.5 generation” as they are first-generation immigrants who enjoy cultural citizenship, but not the protections afforded with legal citizenship status (R. Gonzales, 2016). A unique developmental experience is when youth “find out” about their legal status either through a guardian or by being denied participation in a developmental milestone from their peers. Coming to terms with their undocumented status influences their identity formation processes and worldview. Being faced in a predicament where their notions of belonging are challenged can have traumatic ramifications. Being undocumented has been shown to impact the emotional and mental development of undocumented youth as unique stressors place them at a greater risk for adverse mental health outcomes. Undocumented youth often struggle with issues of a distorted identity formation and a sense of not belonging due to their perceived “alienness” (Gonzales, Suarez-Orozco, Dedios-Sanguineti, 2013).

Dr. Gonzales, a Harvard professor, has researched for over twenty years how immigration influences educational policies as well as educational outcomes amongst undocumented youth. In his book, Lives in Limbo, he notes that being undocumented impacts how individuals interact in their respective educational settings as well as with society-at-large. He posits the trajectory of undocumented students can be contextualized in developmental stages from the pre-awareness phase to the beginning encounters of illegality in adolescence which contributes to the markedly, diverging paths post high school graduation. A pivotal stage in determining outcomes is during adolescence when many become aware of their legal status and are negatively confronted with its implications such as not being able to obtain a driver’s license, obtain a job, or apply to college. The awareness of their “illegality”, financial burden, and other stressors may cause certain teenagers to become what he has nicknamed “early exiters” from the academic trajectory causing them to drop out as early as high school.

Gonzalez contests that being undocumented is the “master status” that defines the sense of belonging amongst undocumented students overriding educational attainment. Thus, being undocumented limits individuals from participating in significant milestones and increasingly narrowing options after leaving the protected confines of education. Graduating high school places undocumented, Latinx youth in a “liminality” position where they are no longer in the same developmental stage as their peers and must transition to adulthood under a non-protected status. As expressed by several youth, this is the paradox of ni de aqui ni de alla which emphasizes the lack of belonging in society (Cervantes et al., 2015; R. Gonzales, 2016; R. G. Gonzales et al., 2013).

On the other hand, “college-goers” constitute a minority of 10% of undocumented, high school graduates who pursue post-secondary education. Counselors have been shown to have significant, positive impacts on the mental health, educational, and post-graduation outcomes of undocumented, Latinx youth as they serve as social capital students can turn to as they navigate the college application and scholarship process (Crawford et al., 2019). The psychological wellbeing of undocumented students in higher education institutions may cause acculturation stress as students cope with their feelings about their documentation status while being confronted with institutional exclusionary barriers (Perez et al., 2009). In the following sections, we will present the undocumented collegiate experience, address risk factors contributing to psychological distress, and highlight protective factors contributing to the wellbeing of undocumented, Latinx students.

C. THE UNDOCUMENTED EXPERIENCE IN HIGHER EDUCATION
Researchers posit the undocumented collegiate experience as unique in relation to their documented peers even when comparing across race, gender, ethnicity, and country of origin (Ellis & Chen, 2013). Key themes identified as being pivotal and unique to the undocumented experience of university students include the following: experiences of pre and post migration, post-graduation experiences limited by being undocumented, need to validate feelings surrounding undocumented status, psychological resilience, high school and college experience as undocumented, a social justice orientation for advocacy of marginalized communities, and fostering community amongst other undocumented students in similar spaces (Cervantes, Minero, & Brito, 2015).

**Psychological Stressors of Undocumented, Latinx Youth in Higher Education**

Studies have also considered a majority of undocumented students hold multiple marginalized identities (eg. race, social class, first-generation, sexual orientation, gender identity) and that the intersection of such identities can create distinct, oppressive experiences not any two individuals will experience the same way (Perez, 2016). For instance, an undocumented, Latinx youth who is a first-generation college student lacks the social capital to navigate “traditional” collegiate experiences such as applying for housing and internship opportunities. Studies have shown the protective duality of such experiences since they can contribute to psychological distress but also help build resiliency (Gamez, Lopez, & Overton, 2017). Often times first-generation college students and even the first of their siblings to pursue post-secondary education (Gonzales, 2016). In a longitudinal study conducted by Gonzales et al. found nearly 50% of undocumented students who pursue a post-secondary education will not graduate with a degree (2016) primarily due to financial constraints. These exclusionary barriers can make educational institutions can function as agents of violence to Latinx students through creating spaces of exclusion which can cause psychological harm (Huber & Cueva, 2012).

**Protective Factors Contributing to Positive Mental Health Outcomes**

**Family, friends, and peers**

While undocumented, Latinx students experience several adverse challenges during their academic journey, there are several protective factors including mentorship from older students, institutional academic support from advisors and professors, and family support that aid in alleviating burdens (Gamez, Lopez, & Overton, 2017; Perez, 2016; Gonzales, Suarez-Orosco, & Dedios-Sanguineti, 2013). Out of all social support systems, several studies have support family as the primary support for undocumented, Latinx students as many fear disclosing their legal status and potential repercussions associated with it (O’Neal et al.) The creation of student organizations on campus serve as support networks in which younger students can seek advice from older students and gain social capital. This supportive exchange is bidirectional as older students cited positive feelings for being able to help younger students navigate such experiences.

**Personal Resiliency**

As defined by the American Psychological Association, resiliency refers to the “process of adapting well in the face of adversity, trauma, tragedy, or significant sources of stress.” Taking an asset perspective analysis of semi-structured interviews of undocumented, Latinx youth ranging from community college to doctoral studies, researchers identified students possessed “individual resiliency” commonly known as *ganas* in Spanish (Gamez, Lopez, &
Overton, 2017). Despite the educational and social barriers, they encountered in academia, *ganas* served as a primary motivator for completing their degree and even pursuing additional schooling at a professional or graduate level. In another study, researchers compared the effects stressors had on the educational outcomes between undocumented and documented Latinx students experiencing depression. In comparison to their documented peers, undocumented students were more likely to express grit as reflected through their academic GPA (O’Neal et al., 2016). In a study examining the effects of migration related stressors on documented and undocumented, Latinx college students, Dornhecker concluded undocumented students presented improved educational and mental health outcomes, particularly in the domain of resiliency. She concluded an increased exposure to risk factors forges resiliency as a protective mechanism and cultural survival skill. These findings support the immigrant paradox in which first-generation immigrants present improved mental health outcomes in comparison to sequential US-born generations (Dornhecker, 2016). Resiliency is reflected in an analysis of educational attainment which showed undocumented students were less likely to drop out of college compared to their documented counterparts even with significant financial burdens (Hsin & Ortega, 2017).

**Civic Engagement**

Differing researchers contest the effects of participating in civic engagement efforts such as advocacy and community groups has on the mental health outcomes of Latinx, undocumented youth. Gonzales, *et al* argue the protective factors of civic engagement as a venue of expression which enables undocumented youth to utilize their experiences and carve a space for themselves in higher education and society. They posit post-secondary institutions can functions as safe spaces where dialogue can occur without a high potential of a legal repercussion (Gonzales, Suarez-Orosco, & Dedios-Sanguineti, 2013). Similarly, Vaquera *et al* propose civic engagement in immigration advocacy groups is the most effective method of coping due to the positive social connections which allow youth to recategorize their emotions. Such connections may help develop emotional capital in the youth such as feelings of empowerment and being proud of their identity (Vaquera, Aranda, Sousa-Rodriguez, 2017). Contrarily, Gonzales *et al* contend that being involved in advocacy groups might be harmful for undocumented youth and hold negative repercussions in several domains (Gonzales, Terriquez, & Ruszczyk, 2014). Nonetheless, there has been a positive increase in the trends of engagement amongst undocumented, Latinx students reflecting a shifting sociopolitical environment (Gonzales & Chavez, 2012).

**Mental Health Service (MHS) Engagement**

However, there is minimal research on the mental health service engagement of undocumented students through traditional counseling mental health services such as individual counseling, support groups, and counseling centers. Previous studies have alluded that counseling centers are one of the last resorts of external help undocumented, Latinx students seek as they would rather engage with family and/or peers (O’Neal *et al*., 2016). Researchers have assessed the factors influencing the mental health service usage of undocumented students despite having access to and coverage for said services. Mental health service engagement was low amongst undocumented, Latinx students because of low perceived treatment efficacy. Students normalized their distress as part of the undocumented experience and perceived the treatment as useless since it would not solve immigration-related issues. Researchers also identified low perceived need and stigma as additional factors inhibiting undocumented students from seeking mental health services (Cha, Enriquez, & Ro, 2019). While these frameworks of support are
built-in, it is unknown whether they are meeting the mental health and psychosocial needs of the undocumented student population on campus.

REFERENCES


Supportive, healthy social relationships are imperative for human health and wellbeing. Prairie voles (Microtus ochrogaster), who mate for life, could hold the key to understanding the molecular basis of how certain animals form selective, lifelong pair bonds. A previous study has shown that both dopamine and oxytocin are required for the formation of these pair bonds. Oxytocin, dopamine, and their respective receptors are present in the nucleus accumbens; the nucleus accumbens is a brain region that is known to be involved in not only pair bonding, but also in motivation and reward processes. More specifically, dopamine 2 (D2) receptors, as well as oxytocin receptors, are known to be required for the formation of these pair bonds. Similarly, the dopamine 1 (D1) receptor is involved in maintenance of these bonds since an upregulation of this receptor is associated with the mate guarding behavior demonstrated by prairie voles, defined as increased aggression towards strangers. Thus, all three receptors are critical for pair bond formation and maintenance. Since the three receptors have not been characterized at the cellular level, the focus of this project is to characterize the mRNA expression and spatial distribution of (D1) receptors, (D2) receptors, and oxytocin receptors in the nucleus accumbens. We investigated whether these receptors are found in the same cells to gain insight into the relationship between oxytocin and dopamine receptors. RNAscope is a new in situ hybridization technology that allows for the simultaneous detection of these receptors at the cellular level through fluorescent probing of mRNA. Preliminary data demonstrates the association of D1, D2, and oxytocin receptors, as all three mRNA probes were visualized within the same cell in both the nucleus accumbens core and shell. Further data analysis will be conducted to quantify the signal of each mRNA probe within a cell; determine if association of the oxytocin receptor with either dopamine receptor varies across sex or nucleus accumbens regions (core & shell) or levels; and ultimately, assess the effects of pair bonding on the mRNA levels of each receptor and its association with the other aforementioned receptors. By studying how prairie voles’ neurological and biochemical pathways affect their social attachment behaviors, we can better understand human social interactions and translate it to mental health disorders that are characterized by impairments of social attachment.
Introduction
Prairie voles as a model for social attachment

It can be difficult to study human behavior and emotion, specifically in the realm of love and social relationships, with one of the reasons being traditional model organisms, such as mice and rats, do not form social bonds. Prairie voles (*Microtus ochrogaster*) can give insight and further expand some of the questions surrounding the driving forces behind social attachments. Prairie voles can help us better understand the chemistry and neurobiological mechanisms in our brains since they are among a handful of mammalian species that form life-long monogamous relationships. By studying how prairie voles’ neurobiology and neurochemistry affect and drive their behavior surrounding social attachments, we can better understand human social interactions.

Requirements for pair bonding
Dopamine is a neurotransmitter that is known to be involved in the rewarding behavior of mammals and plays an important role in these pair bonds. Dopamine is released during mating, which facilitates the social behavior known as partner preference, where a prairie vole will choose to be with its partner when given a choice between its mate and a novel individual. Previous studies have shown that the activation of the dopamine (D-2) receptor appeared to be necessary for partner preference while the activation of the dopamine 1 (D-1) receptor contributes to the maintenance of the partner preferences. This study also looks at oxytocin, a neuropeptide that is also known to be critical for pair bonding and can even substitute the act of mating as a way to a social attachment.

Receptor levels and complex social behaviors
Extensive studies show the importance of the distribution and density of receptors in the vole brain. Receptor distribution varies both across species and within species, and these differences in receptor expression and distribution underlie complex social behavior differences. For example, species differences in vasopressin (V1aR) receptor expression in the ventral pallidum of the brain contribute to differences in pair bonding between monogamous prairie voles and their promiscuous cousins, meadow voles. Additionally, individual differences in prairie vole oxytocin receptor density in specific brain regions modulate the level of alloparenting observed in females. While the upregulation of dopamine receptors has been studied at various timepoints in pair bond formation and maintenance, additional molecular characterization of the dopaminergic cells has not been done.

The nucleus accumbens is a structure that is critical for pair bonding, as well as involved in motivational and rewarding processes. Dopamine and oxytocin signaling revolves around this brain region, which is why it was chosen as our area of interest. Figure 1 shows the two areas of the nucleus accumbens being investigated – the core and the shell.
Although the roles of these receptors have been studied, it is unclear what types of cells these receptors are expressed in – whether the receptors reside in the same cell or different cells. How the dopaminergic and oxytocinergic communicate is not well understood but looking at the location of the receptors relative to each other can provide some insight. In this work, we used the RNAscope technology to visualize the mRNA expression of the Drd1, Drd2, and oxytocin receptors in the nucleus accumbens to gain further insight into the spatial distribution of these receptors and the relationship between dopaminergic and oxytocinergic neurons.

RNAscope is a method in which synthesized probes bind to the mRNA of interest. These synthesized probes are tagged with a fluorophore, and thus allow for the visualization of the mRNA expression and distribution under a microscope. Here we used probes designed for dopamine receptor 1, dopamine receptor 2, and oxytocin receptor. The mRNA fluorescent expression of each of these receptors yields insight into each receptor’s distribution at the cellular level.

**Research aim**

The focus of this project was to characterize the mRNA expression and distribution of the dopamine (D1) receptor and dopamine (D2) receptor in the oxytocin-receptor-labeled neurons of the nucleus accumbens in prairie voles. The mRNA expression and distribution of oxytocin, D1, and D2 receptors was compared between females and males, and between the core and the shell of the nucleus accumbens.

**Methods**

Sample collection: One group of sexually naïve prairie voles was used for sample collection. The group contained eight sexually naïve voles, ranging from 60-90 days old, four of which were female and the other four male.

Tissue processing: The voles were anesthetized by the inhalation of isoflurane. The brains were flash frozen in dry ice and stored in a -80° C freezer until they were sectioned. Prior
to slicing, brains were removed from the -80 freezer and acclimated to -20C for 2 hours. Coronal brain slices (12 µm) were collected using a cryostat that is maintained at -20°C and slides were stored in the cryostat during slicing. After slicing completion, brains were stored at -20C for 2 hours to allow slices to adhere, and then stored at -80C until used for experiments.

*In situ* hybridization: RNAscope methods were used to visualize mRNA expression as per manufacturer’s instructions (ACDBio, RNAscope©) on slices from the eight sexually naïve voles (4 males and 4 females).

Image acquisition: Imaging was done at the CU Boulder Light Microscopy Core in the MCDB department. Confocal images were taken at 40x on the Nikon A1 Laser Scanning Confocal Microscope on both right and left sides of the nucleus accumbens. Five levels of the nucleus accumbens were imaged (Bregma coordinates [1.54mm, 1.18mm, 1.10mm, 0.86mm, and 0.74mm]). Five images were taken per side with 2 images taken for the nucleus accumbens core, and 3 images taken for the nucleus accumbens shell (see supplementary data for map of image sampling). For each level of the accumbens, males and females were imaged in the same sitting with the same hardware and software settings(124,791),(896,995).

Image processing and analysis: ImageJ is a software that is commonly used to process and analyze RNAscope images. Figure 2 demonstrates how ImageJ was used to analyze how many cells are positive for each individual receptor. The cell identification picture is an example of the cells that are stained in blue. That picture is then translated by outlining them in yellow, and a picture of the probe labeling is overlaid. The cells that have signal are then counted.

![Figure 2. Methodology of Cell Counting Using ImageJ](image)

Partner Preference Test: Additionally, 32 independent prairie voles, ranging from 60-90 days of age, were paired for 14 days. All females were primed with 0.1 mL of 20ug/mL of estradiol benzoate for 3 days. On the third day, females were paired with males for 14 days. On day 16 and 18 post-pairing, partner preference tests were conducted. For our partner preference tests, 8 females were the test subject on day 16 and 8 males were the test subject, on day 18. Animals from other pairs were used as the novel animals in experiments to control for sexual naïveté. One male test subject was lost due to overexposure to isoflurane. After partner preference tests, brains were extracted as described above, and females were dissected to
ascertain pregnancy status.

Behavioral Analysis: An automated behavior analysis software, Cleversys, was used to determine which pairs demonstrate the strongest partner preference. The strongest partner preference was determined by looking at how much time was spent with its partner versus the novel animal.

Results
We successfully labeled mRNA expression of Drd1, Drd2, and oxytocin receptors in the nucleus accumbens of male and female prairie voles. Figure 3 is representative image taken of a female prairie vole in the nucleus accumbens core, Bregma coordinates and demonstrates the fluorescence of each mRNA probe.

The microscope images were analyzed at one level of the nucleus accumbens. It shows that the experiment captured the distribution of each receptor with its respective colors.

Figure 3. Fluorescent cells and mRNA expression of receptors after RNAscope in-situ Hybridization

As shown in Figures 4 and 5, there does not seem to be a difference in the percentage of cells positive for each receptor among the voles. There is no statistically significant difference between females and males for any of the mRNA receptor levels examined (Drd1: p = 0.54. Drd2: p = 0.25. Oxt: p= 0.47.) in the nucleus accumbens shell. Similarly, there is no statistically significant difference in the nucleus accumbens core between females and males for any of the mRNA receptor levels examined (Drd1: p = 0.49 . Drd2: p = 0.60. Oxt: p= 0.27.). Notably, the high level of variability in oxytocin levels, particularly with the females may be attributed to by the individual differences in female oxytocin receptor among the female vole population.
**Figure 4.** Positive Cells in the Nucleus Accumbens Shell of Each Receptor, Males and Females, Males: n=3. Females: n = 3

**Figure 5.** Positive Cells in the Nucleus Accumbens Core of Each Receptor, Males and Females, n=3

Figure 5 shows the merged images of dopamine 1 receptor and oxytocin receptor mRNA, and then the merge images of dopamine 2 receptor and oxytocin receptor mRNA. From these images, there appears to be an association between both dopamine receptors and oxytocin receptors, as both receptors seem to reside in the same cells.
Discussion

We did not find a significant difference between males and females in the percentage of mRNA positive cells for any of the receptors examined (Drd1, Drd2, and oxytocin). While we did not test for differences between the core and the shell, the core appears to have lower levels of mRNA expression for each receptor examined.

Additionally, the oxytocin receptor is on both the D1 and D2 receptor, lending into some insight about the relationship between the 3 receptors. Further analysis will determine if there is a bias towards the oxytocin receptor being associated with either more D1 or D2 positive neurons.

The association between oxytocin and dopamine receptors provide some insight into the communication between the dopaminergic and oxytocinergic systems. The close association between the receptors may be explained if the voles have existing receptors that are present for the purpose of creating that selective social attachment with their partner. Paired voles will lend more insight into this theory.

Future Directions

Next steps for analysis include determining double and triple-labeled mRNA positive cells, quantifying the amount of signal, and exploring the distribution of receptors on different levels of the nucleus accumbens. Here, 1 level of the nucleus accumbens is presented [Bregma: 1.54mm]; We will analyze 4 additional levels of the nucleus accumbens at Bregma coordinates [1.18mm, 1.10mm, 0.86mm, and 0.74mm].

In pair bonded voles, there are receptor plasticity changes that occur after bonding. For example, D1 receptors are known to increase in prairie voles after bond formation. There is also
an upregulation of oxytocin receptor expression within females after mating. As stated in the Methods, we have already collected tissue from males and females paired for 14 days and have the corresponding behavioral data of partner preference of these animals. Thus, future experiments will include RNAscope on the male and female paired animals for mRNA expression of Drd1, Drd2, and oxytocin receptors. Comparing the receptor changes in naïve versus pair bonded animals can provide insight into what molecular changes need to happen for those social bonds to form. And in the future whether or not these changes are occurring in diseases that are characterized by impairments in social attachments such as autism and schizophrenia.
Supplementary Sources

Level 1 of the Nucleus Accumbens

Level 2 of the Nucleus Accumbens
Level 3 of the Nucleus Accumbens

Level 4 of the Nucleus Accumbens
Level 5 of the Nucleus Accumbens

Figure 25
Bibliography


Online video games are a rising media format with strong socio-cultural implication. Alongside the immense economic impact video games possess in the United States, video games are becoming important areas of inquiry, allowing researchers to survey culture, interaction, and community politics. Through an ethnographic lens, I have noted ways in which online video games, when viewed as a virtual space and virtual text, facilitate various forms of queer representation and the ability to practice queergaming, two concepts which facilitate the exploration and affirmation of gender and sexual identities and communities in a digital sense.

Literature in video game studies reveal that video games are important conduits that are able to produce, reproduce, and replicate societal norms and values, just as, more generally, “Media texts provide us with source material for what might be possible, how identities might be constructed, and what worlds we might live in.” It is important to note the schools of thought within the field of video game studies. Early critics would worry about internet anonymity and how that would pose a challenge in understanding how video games can be used to understand culture but scholars like Ruberg and Shaw would contend that culture and symbols produced in games are, in fact, indicative of culture at large. Similar to policy taken by people in real life (irl), no decision is made within a space that does not require knowing history, oppression, and context. The same is true for the creation of, and interaction with, online video games. Every game design decision should be viewed as deliberate in the way of drawing upon the current political climate, such as video games only having heterosexual representations in games, which reflects the heteronormativity of current society.

In establishing the analytic framework of this research, it is important to set the terminology used within this research endeavor and answer important questions: What does queer mean? What is queergaming? What demarcates queer representation? How does one define queer representation as seen in online video games and how does one enact queergaming? Starting from the top, the term queer is used in this research to denote sexualities oppositional to heteronormative standards and as a transgressive verb action, seen through the act of ‘queering’

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4 Adrienne Shaw, Gaming at the Edge: Sexuality and Gender at the Margins of Gamer Culture (Minneapolis, University of Minnesota Press, 2015), 3-4.
5 Bonnie Ruberg and Adrienne Shaw, eds., Queer Game Studies (Minneapolis, London, University of Minnesota Press, 2017), Xiv-xvi.
something. Queer does encompass the term LGBT (lesbian, gay, bisexual, and transgender) but during my research I noticed a trend where the term LGBT would be used more formally in game text and spaces for community related topics while gay would be used more colloquially and focused on identity based topics. The verb of queer is the act of dislodging the assumption that ambiguous texts, interactions, and spaces are inherently straight thus allowing the possibility of reading in between the lines for queer content. As such, queergaming is essentially the act of queering concepts within online video games, it is also a “… provocation, a call to games, a horizon of possibilities. Queergaming is a refusal of the idea that digital games and gaming communities are the sole provenance of adolescent, straight, white, cisgender, masculine, able, male, and ‘hardcore’ bodies and desires and the articulation of and investment in alternative modes of play and ways of being.” Queergaming may be summarized as actions taken by queer gamers that is transgressive, that challenges the technonormative matrix: “the digitized, gamified version of Judith Butler’s heteronormative matrix, ‘the matrix of power and discursive relations that effectively produce and regulate the intelligibility of [sex, gender, or sexuality for us.’”

Queergaming bleeds into various forms of queer representation but I differentiate the two terms in order to pose Queergaming as a practice that is autonomous, varied, and ascribes agency to queer players in response to the technonormative matrix, allowing players to chart self-representation and create “… rebellion and utopian rewriting, an attempt to liberate the characters through radical sexuality.”

Queergaming can be understood as a form, or extension, of queer representation but is given nuance in this research to mark the differences that makes up queer representations. Queer representation is inherent to the game and not done by the player, like a game telling players that certain characters are explicitly queer or “allowing” the player to express a limited form of queerness. Paradoxically, this would position queer representation, if separated from queergaming, as a rigid form of representation but still very much queer and without controversy. The intricate complexities belaying queer representation and queergaming recalls the struggle of operating under queer theory when assigning terms. I set these two terms as complimentary, contradictory, and confusing to illustrate the complexities of queer theory and the journey of categorizing representation. Queer representation both notes the affirmational importance of including queer content within a game as an effort for games to be inclusive to queer communities, but also calls attention to superficial representations that are beginning to become prevalent in modern video games to capture the pink market.

6 Edmund, Y Chang, “Queergaming.” In Queer Game Studies, 15
7 Ibid., 15
9 Todd Harper, “Role-Play as Queer Lens: How ‘ClosetShep’ Changed My Vision of Mass Effect” in Queer Game Studies, 133. Where Annika Waern discussed the concept of player and avatars “bleeding” between the lines of reality and fantasy; making it both different and similar. This informs the relationship between queergaming and queer representation.
10 J.P Falzone, The Final Frontier is Queer: Aberrancy, Archetype, and Audience Generated Folklore in K/S Slash Fiction(Western Folklore 64, 2005), 250
Where one is able to witness queer representation and queergaming actualized is through the virtual text of an online video game. Virtual text includes stories, narratives, characters, and other established video game elements, which are also referred to as the narratology of the video game. Clark describes narratology as the “narrative content of a game, sometimes called the dramatic elements, includes characters, plot, fictional world, spoken dialogue, and so forth.”\(^\text{12}\) An example of queer representation through narratology would be a character in a game that is visibly written as queer as indicated by clues in the game itself or by the game company like in the case of Tracer in Overwatch.\(^\text{13}\) An example of queergaming in narratology can be seen in a case where a character’s sexuality is never mentioned or is ambiguous but aligns with the experiences of a queer life. Players would then speculate the character to be queer and relate to the character with similar queer experiences. The same concept of queerly reading the virtual text but done by the player makes it queergaming. By analyzing a game’s narratology as a text, we can see cases of queer representation and queergaming.

In addition to virtual text, we have virtual space, also referred to as the ludology of the game. Ludology positions online videos games as inhabitable spaces, facilitating player interaction, and allows us to view games “as rule-bound play spaces.”\(^\text{14}\) Analysis of ludology emphasizes the relationship between fellow players and game developers, from digital communities to how game developers respond to player feedback. Ludology was a concept that generated controversy in the field, as “…most games scholars now seem to accept that the best way to study video game lies somewhere between the ludology/Narratology divide,”\(^\text{15}\) and argue that ludology can be effectively seen across various forms of media not just games.\(^\text{16}\) Nevertheless, analyzing a game’s ludology is important to see queergaming and queer representation. Queergaming in ludology is queer communities forming within a game, as seen commonly in the creation of many LGBT guilds in relation to games and in using avatars to express gender or sexuality.

With this theoretical framework established, I will ascertain how online video games allow queergaming and queer representation, which can be seen from a game’s narratology and ludology. Specifically, I will break down certain areas of queergaming and queer representation done in games by players, as ascertained from data gathered from a two segmented participant observation processes from three games. These games are World of Warcraft (2004), Star Wars the Old Republic (2008), and the Secret World/Legends (2012). All three games are MMORPGs, which stands for Massive Multiplayer Online Role-Playing Game, often shortened to MMOs. MMOs share the core mechanic where a human person must make an account then create an avatar, or player character, to explore and play the game. From within the game the player character interacts with other human players who also populate the online game, as such internet access is required. All three games have remained in the market for quite a while and thus have established online communities. World of Warcraft, WoW for short, is perhaps the oldest and

\(^{12}\) Naomi Clark, “What Is Queerness in Games, Anyway?” in *Queer Game Studies*, 8.

\(^{13}\) Paul Tamburro, *Tracer is Officially Overwatch’s First LGBT Character*, 2016.

\(^{14}\) Adrienne Shaw, *Gaming at the Edge: Sexuality and Gender at the Margins of Gamer Culture*, 37.

\(^{15}\) Ibid., 37

\(^{16}\) Ibid., 105
largest MMO game and is considered the gold standard for competitors in the MMO genre. The company Blizzard Inc, which recently combined with another company named Activision, created WoW. Blizzard Inc. which created other notable games like the Diablo series and the recent first-person shooter Overwatch (2016). WoW is one of the few MMOs in existence that still requires a person to purchase the game and maintain a monthly subscription, which is $15, in order to continue in playing the game. Stars Wars the Old Republic is an MMO created by the company BioWare, a game company notable for creating the Mass Effect game series and Dragon Age games series, games that allow same-sex romance and experimentation. BioWare is one of the few big-name companies to allow this within their games. Stars Wars the MMO is part of the Star Wars Franchise and shares the fan culture of all things Stars Wars but retains a unique community for its MMO. In contrast to the older game of WoW, Star Wars is younger and has queer representation that is gated beyond DLCs (Downloadable Content) but is initially free to play. Finally, the game of Secret World/Legends, which is a more niche game compared to the other two title, was created by Funcom Inc, a company that is credited as being one of the oldest gaming companies that produced MMOs. The game first launched as The Secret World (2012) where players had to purchase the game and retain a monthly subscription similar to WoW. Due to the lack of player population and investment, the Funcom relaunched the game as The Secret Legends (2017). Currently there is a small niche online community playing The Secret Legends.

My participant observation involved solo playing the game and interacting with public chat channels and players that were not initiated by me. I devoted around 10 hours a week for a month period for all three games. This was to become familiar with the context of a game’s ludology. I did not conduct interviews within the game or initially start dialogue about my research. I was only a part of the digital environment and learned a great deal of the context of each game but not much in the way of learning about queer representation and queergaming. The second part of the participant observation yielded more results in the way of queergaming and queer representation from the game’s ludology and narratology. The second part involved gathering data from forum posts on each game’s website. Typically, MMOs have a corresponding website that houses forums so players can talk and post about the game. Topics posted within forums vary substantially and therefore are categorized into a myriad of topics from players discussing the game itself, issues with the game software, the intricacies of the games story, and other miscellaneous discussions. I accessed three websites aligned with the respective games, WoW, Star Wars, and Secret World/Legends, and searched through the general forums of each game. In order to access modes of queergaming and queer representation, I used the keyword terms of “gay” and “LGBTQ” in the forums under the general discussions tab. Then I read each post that had the term within it and the thread the post was in.

The method I used to evaluate these posts is largely qualitative where I gleaned patterns that are shared between all three-forum websites along with certain particularities unique to a certain game. I also wanted to add my personal testimony to the participant observation. Inspired by the works of Gloria Anzaldúa, which includes the experience of the self in writing and
establishing a consciousness of pre-knowing, I will supplement these analyses with my own experience of games as I played these games before I targeted them for research.

For WoW’s, where forum posts n=101, I had to limit analysis to 101 posts due to the game’s age and popularity that offered a substantial forum post count. Therefore, the post gathered from WoW represents posts from the first quarter of the year 2019. This contrasts to the data gathered from Star Wars (n=79) and The Secret World/Legends (n=21) where all forum posts were comprehensive from the key term search. First, I will note general trends about Queer representation and queergaming across all three game with evidence from forums posts. Then I will go into queer Representation and queergaming examples that were unique to a certain game.

Immediately, I noticed there was a difference in results when searching through forums posts between terms gay and LGBT in all three game forum sites. LGBT would be used more formally or relating to a search for community with common threads advertising LGBT Friendly guilds, while the term gay would be used informally but placed in either highly contentious arguments or whimsical contexts usually relating to identity politics.

In the case of the search word LGBT, many MMO’s share a mechanic titled “guilds.” A guild is a member’s club of players who can play the games content together and have access to a separate chat room for players within that certain guild. Being part of a guild is a significant part of the experience of playing an MMO. Typically, players are able to create a guild with a handful of other players and soon after other players have to request membership in order to be part of a guild. Seen in many forum posts throughout the games, many players, presumably queer, are looking for LGBT Friendly Guilds. While not all LGBT Friendly Guilds are comprised of majority queer players, Sometimes LGBT Friendly is code for a queer guild. LGBT Friendly is synonymous with being tolerant of LGBT sexualities and does not necessarily shield queer players from homophobia and sexism often found in games. This sentiment of finding a community that is LGBT Friendly stems from the fact that queer players must navigate a medium thought to be dominated by the white straight male player and the reality for many marginalized gamers is that gaming communities are heavily masculine and highly toxic. This action, the formulation of LGBT Friendly guilds and constructing of anti-homophobic digital spaces, would be a praxis of queergaming in the game’s ludology.

The search for “LGBT Friendly” drastically dominates many forums posts relating to queerness between all three forum websites. Almost all The Secret World/Legends and Star

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17 Gloria Anzaldúa, *Borderlands = La frontera The New Mestiza*. (San Francisco: Aunt Lute Books, 1999). I introduced pre-knowing to address that in my experience, I was familiar in ways in which I would navigate gender and sexuality online compared to real life before coming into contact with academia. It was similar to Anzaldúa ideas of a person carrying knowledge from living between two worlds, in her cases the borderlands. However, I am manifesting parallels of positing video games as borderlands.

18 Search results for World of Warcraft Forums using ‘LGBT’.

19 Original Post of “Unofficial LGBTQI+ Friendly Guilds Registry – Advertise Here,” World of Warcraft Thread, 2019

20 Original Post of “Gay Relationships,” Star Wars Thread, 2012
Wars posts, around 80%, deal with different players asking for LGBT friendly guilds. Queer players, by letting their concerns be known and vocalizing their search for a safe community in video games, challenges the technonormativity within games and goes beyond measuring forms of queer representation. In a Star Wars thread there was a question of the relevance of LGBT Friendly Guilds and one poster defends it by saying “… its so we can have representation and a positive community in the game and be in guild where you don’t HAVE to worry about an officer being a bigot.” These public forums are able to provide dialogue centered on queer issues that exposes the technonormativity inherit within games, for example, one poster in WoW states “…I think LGBT friendly should be the default assumption rather than a descriptor for guilds…” (this poster met resistance in challenging on why guilds in WoW have to advertise tolerance to a certain population). While important information is being drawn from some forum posts, important questions remain such as, how queer are LGBT Friendly Guilds? What are the specific ways LGBT Friendly Guilds protect and promote their queer players? These questions highlight the limitation of using participant observation of forum posts: only seeing the initial ask but not the follow-up, which might reveal the actual experiences of queer players in LGBT Friendly Guilds.

Another pattern across games would be experimentation or affirmation of player gender and sexuality through the uptake of different avatars. In all three MMOs, a human player can express themselves through a multitude of avatars, or player characters. These player characters represent the virtual self of the human player within the game as one poster states that “… my in game character is a projection of myself…I do however treat in game females like females though because that is the avatar they choose to play as.” This similar to Shaw’s research on the importance of avatar expression. One of her interviewees echoes the sentiment from before and states that, “even if I decide to choose a seemly random selection of options from a character-customization screen, I must momentarily reflect on how much I care about how I am represented in the game.” The sexuality of many player characters throughout all three games is never explicitly stated or indicated. Gender is more rigidly placed in a binary within avatar customization. Therefore, when a player expresses, experiments with, or affirms, gender through cross gender play it would be another example of queergaming in ludology. This is because the player has a hand in expanding the expression of the avatar that the game did not foresee, such as

21 Original Post of “Templar Character LF LGBT Cabal”, Secret World Thread, 2014
23 Original Post of “[Illuminati] Soulweavers is brand new and recruiting! (And LGBT friendly! )”, Secret World Thread, 2012
24 Response in, “LGBT Players – Check in Here!” Star Wars thread, 2012
25 Response in, “The Community Today Vs Years Past” WoW thread, 2019
26 Response in, “Is it weird for MALES (irl) to play FEMALE characters in game?” WoW Thread, 2019
27 Adrienne Shaw, Gaming at the Edge: Sexuality and Gender at the Margins of Gamer Culture, 102
the player envisioning a journey of a queer Jedi, which disrupts the assumption that Jedi are heterosexual.

Experimentation is looser to define, compared to affirmation. Some trans players may use avatars to reaffirm their gender identity, which is different than experimentation, as experimentation implies playing the “other” gender. In one WoW thread titled, “Are you the game gender as your toon,” one player, Rosenivy, responds “ehhh…yes and no depending on who you ask. I’m female to male trans. However, with some people I would still ‘technically’ be female,” and another poster responds with “Don’t listen to those people. You are male and you are valid.” Shortly after, within the same thread, another poster, Hatred, responds with “Indeed I am! Is cis gay male a thing? Because that would be me.” These two responses show an example of gender experimentation and affirmation. Rosenivy identifies as a man and plays female characters, which could be understood as experimentation but is also facing resistance on his identity and complicates the narrative of perceiving gender. Dissimilarly, Hatred, the cis gay player, uses the avatar to project his gender and queerness in a jovial way. Nevertheless, both players are exhibiting different ways of queergaming in ludology through differing practices of expressing gender and sexuality through avatars.

Curiously, cross gender play is popular for straight cis players for drastically different reasons. Many non-male players use male avatars to avoid harassment from male players where one player states, “I am not a male IRL. But I’ve found that I get treated with more respect in game if I play a male character…” Many cis straight male players play female avatars because of the aesthetic and appearance thus asserting their male gaze onto the female digital person. Many discussion posts often question the masculinity and heterosexuality of men who play female characters, as there is a theme of anxiety around masculinity on the WoW Forums. While queer and trans players use avatars for expression and affirmation, which is evidence for queergaming in ludology, straight players experimenting with gender in avatars poses an entirely different question but is a significant pattern that is shared between all video game websites.

So far, I have discussed how the games WoW, Star Wars, and the Secret World/Legends forum posts revealed two substantial patterns of queergaming in ludology. In my research, I saw examples of queergaming in narratology from the World of Warcraft forums posts surrounding the character of Anduin and Wrathion and queer representation in the NPCs of The Secret World/Legends. First, in World of Warcraft, I noticed a correlation where the game itself has a severe lack of queer representation thus requiring many players to queergame. In the context of Anduin and Wrathion, two young male characters in the game stories, many players are

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28 Original Post of “RP Leveling with my Gay Jedi? (Bergeren Colony)”, Star Wars Thread, 2013
29 Response in, “Are you the same gender as your toon?” WoW Thread, 2019
30 Response in, “Are you the same gender as your toon?” WoW Thread, 2019
31 Response in, “Is It Weird for MALES(irl) to play FEMALE Characters ingame?” WoW Thread, 2019
33 Andrea Braithwaite, “‘Seriously, Get out’: Feminists on the Forums and the War(craft) on Women.” New Media & Society 16, no. 5 (August 2014), 703-18
interpreting their relationship to be queer. Anduin is a son of a king whose sexuality is never disclosed but players are noting the lack of female attraction Anduin has in addition to having an imitate platonic relationship with the character Wrathion. Many players are taking the forums and creating the dialogue around Anduin’s sexuality that also reveals the lack of explicit queer representation in one of the oldest MMOs. In the case of Anduin and Wrathion, WoW players are exercising queergaming in narratology by queer reading the text and interactions between two NPCs and imaging them as queer experiences. This transgressive reading of game elements is supplemented by the discourse happening in the forums, similar to the action of looking for LGBT Guilds and its subsequent conversation of the status of queer gamers and communities in games. Many players in WoW are applying queergaming to other characters, although Anduin and Wrathion is often the prime example, throughout the game and engaging in conversations with other players about the lack of queer representation in games and how queer reading can be implied and mirror irl queer experiences. It is interesting to see that many players, queer and otherwise, believe Anduin’s queerness to be a fact. In addition, many criticisms rely on the relevance of his homosexuality and do not refute his queerness.

For the Secret World/Legends, I noticed a subtle medium level of queer representation and low levels of queergaming. The game, and players have noticed, has characters that express their queer sexuality and offers scenarios where a NPCs flirts with the player regardless of their gender. The player character’s sexuality in the Secret World is never set and players are supposedly mute so there is no option to reciprocate advances, although a player expressing and imaging their character as queer would remind us of queergaming in ludology. Because the player character is mute in the Secret World, they can only listen to dialogue. Additional dialogue is optional and only adds depth to the narrative of the game, therefore, many players are able to skip the additional dialogue options. Unlike World of Warcraft, which offers no explicit queer characters, the Secret World does, so the game offers players a limited scope of queer representation in narratology. “Limited” in scope is warranted as the select queer characters sexuality is not center stage and players would have to pay attention to the subtle clues a NPC drops within an additional dialogue option. The Secret World offers an example that demarcates the application of queergaming and queer representation within a video game text and space. One player best explains The Secret World queer representation in the following response, “When I came back and paid a bit more attention, I was surprised to note that not only where there lgbt npcs in the game, but not a single one wore neon-coloured clothing covered in

34 “Anduin is just so obviously gay. He’s a holy priest. He’s never expressed any interest in any woman until BfA, but tha’s only a cover up to keep Uncle Greymane happy. Anduin really has his heart set on the black dragon. In one of the parts of the legendary questline in MoP, you go upstairs to see Anduin and Wrathion sleeping in the same bed in just their boxers, Wrathion gets up panickedly and sends you to Throne of Thunder to to get 12 of a useless item that never drops, just so he can spend me alone time with Anduin. Throughout Mists, the questline would send you upstairs to see Wrathion only for you to interrupt one of their crazy sexcapades.” A response in “Wrathion and Anduin?” WoW Thread, 2019
35 Response in “When is Anduin going to settle down?” WoW Thread, 2019
36 Response in “Your lore character crush.” WoW Thread, 2019
37 Original Post “I MISS JAINA X VEREESA,” WoW Thread, 2019
generally ‘cutesy’ pictures, spoke with that weird half-lisping half-teenage-girl voice that every gay character in fiction seems to use.”38 Regardless of the homonormativity displayed by this particular responder, many Secret World players applaud the inclusion of queer representation in narratology.

In stark contrast to the Secret Worlds non-talker player characters, BioWare’s MMO adaptation of Star Wars allow players to talk. The game allows certain degrees of freedom where players are able to flirt with NPCs. This extends to level of expression in terms of romance and sexuality. In Star Wars, the line blurs the application of queergaming and queer representation. This is seen in how the game allows for the player to queergame by letting the player to enact same-sex romance and marriage. By game design this would be queer representation but the players are still very much playing queer that upsets a fandom setting, the Star Wars franchise title in an MMO genre, thought to be solely the realm of technonormativity. Therefore, Star Wars offers players a way of hybrid queergaming and queer representation, but that was not originally the case. Within the first years of when Star Wars the Old Republic launched, the base game did not have any queer representation within the story and romances only allowed different sex couples. It was until recently that Star Wars included two cases of adding a duo of bisexual characters in expansion packs. Players called the first case the “gay”39 planet, to denote the one character that flirts with the player regardless of their gender. BioWare later added more queer representation by adding Theron and Lana, two important characters that the player has to interact with within the linear storyline of Star Wars. Their sexuality is never revealed and the player is not aware of a queer possibility, in my experience with playing a male character and interacting with Theron, a male NPC, the initial greeting was different compared to my interaction with Theron when I was playing my female character but the subsequent romance seems to be the same for both avatars. Star Wars is not subtle in romance as the player can choose the “Flirt” dialogue option but in regard to romancing Theron, or Lana, it requires always using the Flirt option whenever it is allowed. What is striking about this Flirt Option is that it is visible for all players to see. Many players are confronted with the possibility of flirting with a same gender character compared to the lack thereof in the base game.

This is just a short glimpse at the potential of queergaming and queer representation seen in the narratology and ludology of online video games. Online videos games offer transgressive texts and spaces to allow various forms of queer representation and the practice of queergaming. But queer players also must navigate the ways in which video games reproduce harmful traditions that encode cisheteropatriarchy and take advantage of queer productions of self-representation. In the future, I hope to further my research and conduct a substantial ethnography to represent how queer players view and enact queer representation and queergaming as well as to expand the conversation of inclusivity within online video games.

38 Response in “Thank you for LGBT representation in The Secret World,” Secret World Thread, 2015
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Parental Health and its Impact on their Child’s College Trajectory

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While researchers have studied several factors related to college trajectory among youth, minimal research has explored the association between parental health and its influence on their child’s college trajectory. Since parents play instrumental roles in preparing students for college, consistent with the linked-lives phenomenon, I expect that a parent burdened with poor health during the key points in their child’s life may shape their child’s college going status during the transition to adulthood. Using a sample of young people drawn from the National Longitudinal Study of Adolescent Health dataset, I estimated a set of logistic regression models that examined the degree to which self-reported parental health is associated with college-going status, net of family-level characteristics. Overall, a respondent with a parent in bad health has nearly a two-thirds lower chance of being enrolled in college compared to respondents with parents in good health. This study illustrates that parental health may hold a significant influence in explaining the variation in college-going status. When linking health status and college attendance to later socioeconomic status, this study points to the way health is a resource that can contribute to the intergenerational transmission of dis/advantage.

Keywords: Parental health, education, college enrollment, life course

Introduction

College attainment and completion is an increasingly significant indicator of socioeconomic status in the United States, as more jobs require individuals to earn postsecondary degrees for both entry-level positions and promotions (Carnevale et al., 2013). Additionally, the Bureau for Labor Statistics projects an inverse correlation between the number of degrees an individual attains and lower unemployment rate (2018). Yet, access to universities and colleges
continues to be highly stratified. For example, low-income students remain underrepresented at four-year universities and colleges (Walpole 2003; Fry & Cillufo 2019). While scholars have considered family-level barriers to education, such as race, parental educational attainment, and family income (Perna 2007; Augustine 2014; Rowan-Kenyon 2007), this paper focuses on parental health and intends to highlight the association between parental health in adolescence and later college enrollment.

Scholarship illustrates how parents and their acquired resources are related to their children’s quality of life across their early life course (Elder, 2003; Laureu, 2011). Another aspect of the family that may shape college-going is the role of parental physical health on college enrollment. Rising morbidity and mortality rates among U.S. adults in midlife, compared to those in peer nations, is increasingly documented within literature (Case & Deaton, 2015). Importantly, acute or chronic health issues can emerge while adults are raising their offspring. In other words, parents who are in poor health and feel bad may be less effective in supporting their children as they navigate academic challenges and setbacks or prepare for the rigors of college through advanced placement/dual credit courses in high school. At the same time, children with ill parents may be less engaged in school, and more focused on caring for their sick parent or other siblings and finding other sources of support and status with peers. Therefore, parental health, above and beyond parental race, educational attainment status, and socioeconomic standing, may be linked with the likelihood of college-going during the transition to adulthood.

Consistent with the life course theory, the linked lives phenomenon may serve as a channel through which disadvantage (bad health) in the parental generation may impact their child’s wellbeing in young adulthood (Elder et al., 2003). Using two waves of data from the National Longitudinal Study of Adolescent and Adult Health, I explore the association between a parent’s report of health status during their child’s adolescence and their child’s college enrollment status during young adulthood, analyzed through objectives. First, I determine the period of the academic transition to college among my sample population. Next, I identified which part of my sample had parents in poor health. Then, I analyzed the correlation between the students’ college trajectory and their parent’s health status. Lastly, I explored mediators acting as a buffer towards students with parents in bad health.

**Educational Prospects & Enrollment**

College attendance among our current generation continues to be an important marker of success in America, a rising 67% of jobs in our marketplace require some sort of postsecondary education (Watt et al., 2011). Earning a college degree has a positive correlation with better health throughout adulthood (Ma et al., 2016) and more stable marriages (Copen, 2012). Additionally, these benefits transfer downward to one’s children as well, who see a higher chance of attending college with parents who themselves have earned degrees (Ma et al., 2016). While equal college access for all seems to be our nation’s goal, the populations earning degrees in our nation continue to vary by race and class. This ultimately contributes to the stratification of socioeconomic status in America.

Understanding the college-going status of a young person is vital in understanding the sources of stratification. In other words, factors across the early life course such as the young person’s skills, motivation, and performance; parents and other adults support and supervision contribute to the likelihood that a student is enrolled in college. During the transition from middle school to high school, parental input aids in helping their student(s) discern which classes
to pursue, especially as a means to prevent them from falling off track. For instance, subjects such as mathematics are hierarchically ordered, with advancement in the math track requiring the successful completion of courses within the sequence (Cavanagh et al., 2006). Exposure to rigorous courses within the hierarchical sequence has a larger chance of preparing students for more rigorous tracks as they pursue post-secondary education, such as subjects within STEM and college in general (Ma et al., 2016). Additionally, while the exposure is necessary, performance in those classes help predict the likelihood of a student’s overall attendance in college directly after high school. Thus, the focus of this study is on the likelihood of college enrollment in early adulthood.

Linked Lives and Parent Health

In the US, the population entering midlife has been noted to increasingly encounter higher rates of mortality and morbidity. Although life expectancy was about 77 at the start of the Add Health Study, rates of morbidity among adults in midlife (approximately 40-55) were high and have increased over the past two decades (Case & Deaton 2015). In 2000, for example, about 30% of adults aged 40-50 were obese (Hales et al., 2017) and just over 10% of adults 35-64 had diabetes (Cheng et al., 2013). It is likely that many of these adults captured in these estimates are also parents. It is also plausible that morbidity in midlife may be linked to how effectively these parents parent and support their children, especially as it relates to their educational careers.

So why might parental health be linked with young people’s educational attainment? Lareau’s (2011) research highlights the central role of parenting in leveraging resources and cultivating skills and dispositions in children that can increase the likelihood of college going. A parent who is in poor physical health may, above and beyond other markers of social location, be less able to support their children in middle and high school. These parents may be physically unable to attend school events or help their children with schoolwork because they feel bad or have limited time or energy to manage children’s educational careers along with other tasks associated with supporting their household while sick. So, the level of parental involvement acts as a mechanism through which a parent’s own health can hinder or advance their child’s college trajectory.

Another mechanism that might link parental health with college going is related to young people’s own orientation to school. Children with a parent in ill health may feel additional stress. In a study looking at households with a parent dealing with Parkinson’s disease, children reported experiencing low quality of life due to the burden of helping out daily, as well as negative reactions from friends (Scharg et al., 2004). Considering the layer that academics contribute to a child’s quality of life, children in these situations may become less engaged at school since their focus might be more on trying to be available to help out their household. Additionally, time may also become more prioritized toward family obligations. With low engagement in the classroom and less time dedicated toward academics, students may skip out on the rigorous curriculum needed to boost their likelihood of enrolling and succeeding through college.

It is not clear whether parental involvement or children’s engagement in school has a larger impact on a young person’s college trajectory. Nonetheless, good reasons exist on both the parent’s and the child’s side in understanding how parental health is linked with a young
person’s college trajectory.

Methods

Dataset
Data for this study was obtained from the National Longitudinal Study of Adolescent to Adult Health (Add Health), a nationally representative sample of school going adolescents in 1995. Currently, five waves of the Add Health survey have been conducted, with each wave following the original participants of the survey and studying their transitions and behavior through life (Bearman, Jones, & Udry, 1997). In my study, I use the public-use version of Wave 1 (n = 6,506) and Wave 3 (n=4,882) data. These waves were merged and used to study young people and their parents’ responses in Wave 1 to predict college enrollment (Wave 3). Wave 1 was conducted between 1994-1995; Wave 3 was collected between August 2001 and April 2002 when the respondents were between the ages of 18 and 26 years old. The analytic sample used in the analysis consisted of respondents who completed both Waves 1 and 3, had no missing data for all control variables, and had left high school (N=3,667).

Independent Variable
The measure of parental health was asked in the in-Home survey of Wave 1, stating: “How is your general physical health?” Respondents answered on a scale of 1 (excellent) to 5 (poor). This item was recoded into a dummy variable where those who reported being in fair or poor health were considered in poor health (1) and all others who reported good, very good or excellent health were placed in the reference category (0). Previous studies analyzing an individual’s overall health were indicative of accurately forecasting the respondent’s health levels via self-reported scales (McGee, 1999).

Dependent Variable
College enrollment status is gauged by using the following question on Wave 3, “What is the highest grade or year or regular school you have completed?”, with answer choices ranging from 6th grade up to 5 or more years of graduate school. A dummy variable was coded into two categories (0 or 1, respectively), for students who had not attended college (12th grade and below at Wave 3) and students who were currently enrolled in college or had any college education (1 year of college or more).

Covariates
GPA of the student respondents in Wave 1 was constructed using the most recent grades of the core classes the students had taken in school (prior to postsecondary school). Two courses—English and Math—were used to compute GPA on a 4.0 scale (with A = 4 and D or lower = 1). Students without grades for one of those classes had their GPA computed with other core subjects, such as History or Science. Student’s desire to attend college was also included as a variable, based on a question asking students how much they wanted to attend college (1 = Low and 5 = High).

Control Variables
Control variables included in this study are parent reports of family income at Wave 1, child sex, age of parent, and race of the respondent. Income was based upon the question given to the respondent’s parent/guardian who filled out the questionnaire in Wave 1. In order to
correct for the non-normal distribution, income was logged. Additionally, to save respondents from potentially being removed from the sample for omitting their income, mean imputation according to race was conducted. The sex of the adolescent respondent from wave one was renamed and included as a bivariate control variable within the logistic regression ran for the sample. Race was also included as a series of dummy variables: non-Hispanic White, non-Hispanic African American, non-Hispanic Asian American, non-Hispanic American Indian, and Hispanic/Latinx.

Analytical Approach

The first two goals of the study required determining and creating measures that illustrated parents’ self-reported health status and young peoples’ college trajectories at the end of high school. The total observations and means of independent, dependent, and explanatory variables are presented in Table 1. For the final goals of this study (evaluating the association between parental health and college status), a set of logistic regression models were estimated to predict whether the health status of their parent’s was associated with the odds of being enrolled in college, net of control variables. Three models were constructed from the computed regressions, with Model 1 illustrating the focal relationship between the parental health and college status, Model 2 incorporating the control variables, and Model 3 including the young person’s GPA and desire to attend college as mediators. Sampling weights were included to adjust for the sampling design of Add Health.

Results

Looking at the descriptive results illustrated via Table 1, just over one in 10 students had at least one parent with bad health (12.4 percent). Additionally, a large majority in the sample were currently enrolled in college at the time of Wave 3 (65 percent). Non-Hispanic white respondents comprised the majority of the sample’s population (61 percent), while non-Hispanic Black respondents were the second largest group (21.5 percent). Female participants make up more than half of the sample. The average income per family was under $50,000. Average GPA (calculated from Wave 1) of students was recorded as 2.803 on a scale of 4.0; most of the respondents shared a high desire to attend college when asked in Wave 1.

Moving onto the multivariate analysis of this study in Table 2, Model 1 presents the focal association between self-reported parental health and college enrollment status. A respondent with a parent in bad health has about a two-thirds lower chance of being enrolled in college compared to respondents with parents in good health. Controls related to individual and family characteristics were included in Model 2, including race/ethnicity, gender, age, and family income. While the odds ratio was slightly attenuated, it remained statistically significant. Respondents with parents in bad health experienced a 43% decline in the likelihood of being enrolled in college compared to respondents with parents in good health.

The final model includes indicators that tap young people’s orientation to school, including their GPA and motivation to attend college at Wave 1. Model 3 illustrates a significant and positive association between the desire to attend college, GPA, and college going. In other words, young people who did better in school and reported a greater desire to go to college at Wave 1 were more likely to be enrolled in college at Wave 3, net of other factors. Importantly, the odds ratio associated with parent health and college going changed little upon including these two factors. Therefore, the impact of parental health on college enrollment status continues to be
consistently significant across all three models.

**Conclusion**

This study illustrates that parental health holds a significant influence in explaining the variation that occurs among the college going status of young adults. As this field continues to expand, it is important to provide resources to families with unhealthy parents via communities, school districts, as well as the government. Additionally, further research will help researchers understand the detrimental effects that a parent’s health status may unintentionally hold upon their child’s transition into adulthood.

When reflecting on the scope of this study, one limitation that may have affected this study is the sample size of my dataset. The public-use version was used to conduct this study, which may have limited certain populations or reduced how well my final sample would be reflective of the U.S. national population. Access to the restricted version of ADD Health via future studies will aid greatly in ensuring proper representation and more accurate results. While the use of self-reported health ratings was used to quantify parental health, the differences around the impact of poor physical health compared to poor mental health remain unclear. Future studies may require clearer distinctions between each type of health to properly analyze its impact on their adolescents.

Moreover, identifying the best way to capture the mechanism through which a parent’s health influences their child’s college status served as another limitation to this study. Questions within ADD Health did not precisely quantify parental involvement at earlier waves; therefore, the focus of this study was to focus on identifying the focal relationship between parental health and college status in order to support further work exploring the mechanisms through which this phenomenon occurred. Therefore, exploring other datasets centered around the family, child-rearing, and health may provide additional avenues to studying explicit mechanisms. Future studies in this area should capitalize on better defining parental health, as well as accurately capturing when it has the most significant effect in a young person’s life. Lastly, looking at how a parent’s health influences how long a student decides to delay college attendance can provide an opportunity to capture other students left out of this survey.
Table 1. Key analytic measures by parent health status (n = 3667)

<table>
<thead>
<tr>
<th></th>
<th>Poor health (n= 460)</th>
<th>Not poor health (n=3207)</th>
</tr>
</thead>
<tbody>
<tr>
<td>College Attendance at Wave 3</td>
<td>44.30%</td>
<td>65%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Young adult characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender (female)</td>
<td>52.4%</td>
<td>53.8%</td>
</tr>
<tr>
<td>Age at Wave 3</td>
<td>21.626 (1.80)</td>
<td>21.661 (1.70)</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Hispanic White</td>
<td>48.2</td>
<td>64.1</td>
</tr>
<tr>
<td>Non-Hispanic, Black</td>
<td>25.3</td>
<td>20.9</td>
</tr>
<tr>
<td>Non-Hispanic, American Indian</td>
<td>5.7</td>
<td>2.8</td>
</tr>
<tr>
<td>Non-Hispanic, Asian</td>
<td>2.6</td>
<td>3.6</td>
</tr>
<tr>
<td>Hispanic</td>
<td>18.1</td>
<td>8.6</td>
</tr>
<tr>
<td>GPA</td>
<td>2.623 (0.83)</td>
<td>2.820 (0.84)</td>
</tr>
<tr>
<td><strong>Family characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parent age</td>
<td>42.9 (7.76)</td>
<td>41.4 (6.01)</td>
</tr>
<tr>
<td>Family income</td>
<td>$28,334.43 (33,534.41)</td>
<td>$52,238.21 (58539.38)</td>
</tr>
</tbody>
</table>
### Table 2: Odds ratios predicting college attendance at Wave 3

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor parental health</td>
<td>0.36***</td>
<td>0.37***</td>
<td>0.38***</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.05)</td>
<td>(0.06)</td>
</tr>
<tr>
<td><strong>Young adult characteristics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1.72***</td>
<td>1.36**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.16)</td>
<td>(0.14)</td>
<td></td>
</tr>
<tr>
<td>Age of Respondent (Wave 3)</td>
<td>0.96</td>
<td>1.04</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td>(0.03)</td>
<td></td>
</tr>
<tr>
<td><strong>Race/ethnicity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Hispanic, Black</td>
<td>0.64***</td>
<td>0.72*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.08)</td>
<td>(0.10)</td>
<td></td>
</tr>
<tr>
<td>Non-Hispanic, Native American</td>
<td>0.71</td>
<td>0.86</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.18)</td>
<td>(0.23)</td>
<td></td>
</tr>
<tr>
<td>Non-Hispanic, Asian</td>
<td>1.60</td>
<td>1.46</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.45)</td>
<td>(0.38)</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>0.66**</td>
<td>0.76</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.10)</td>
<td>(0.13)</td>
<td></td>
</tr>
<tr>
<td>Non-Hispanic, Other</td>
<td>1.29</td>
<td>1.48</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.50)</td>
<td>(0.73)</td>
<td></td>
</tr>
<tr>
<td><strong>Parent/family characteristics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age of Parent (Wave 1)</td>
<td>1.06***</td>
<td>1.07***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
<td></td>
</tr>
<tr>
<td>Family Income (logged)</td>
<td>1.23***</td>
<td>1.15**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.07)</td>
<td>(0.05)</td>
<td></td>
</tr>
<tr>
<td><strong>Academic orientation at Wave 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GPA</td>
<td>2.30***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.15)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motivation for College</td>
<td>1.86***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>1.66***</td>
<td>0.03***</td>
<td>0.00***</td>
</tr>
<tr>
<td></td>
<td>(0.08)</td>
<td>(0.03)</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Observations: 2,958, 2,958, 2,958

***p<0.001, **p<0.01, *p<0.05. All results reported as odds ratios (OR)
Standard errors in parentheses.
Robust seeform in parentheses. All coefficients reported as odds ratios.

*** p<0.001, ** p<0.01, * p<0.05
References


Cosmic Ray Detection using Silicon Photomultipliers

Emrys Peets
The University of Texas at Austin
Greg Sitz, PhD, Faculty Mentor

In large collaborations such as the Muon to Electron and Light Dark Matter Experiment, the need to characterize cosmic ray muons is ever-increasing. In this experiment, a small detector, known as a silicon photomultiplier, is coupled to a scintillator. The scintillator is triggered by a photomultiplier tube and used to characterize these cosmic ray muons. Data was collected for this experiment at the California Institute of Technology as part of a WAVE Research Fellowship during the summer of 2019. I compared the calibration factor obtained based on a peak-height data collection method from an LED ((515.8 ± 50.70) ADC Channels) to a calibration factor obtained from $^{90}$Sr. ((538.6±43.22) ADC Channels). This gives a final ratio of agreement of 1.04. ± .10. Finally, I used the $^{90}$Sr calibration constant to find the average number of photoelectrons of a cosmic ray source distribution to be $$(65 ± 6.9)$$ photoelectrons.

1. Introduction

For this experiment, cosmic ray muons were detected and characterized using a scintillator coupled to a silicon photomultiplier (SiPM). The SiPM collected data by triggering off of a photomultiplier tube (borrowed from the Sitz Lab) set to discriminate noise on the range of sub 20 photoelectrons. The data was parsed into a histogram based on the peak-heights using a digitizer as a collection method, and the average energy of the muons were determined by a calibration using $^{90}$Sr. In this experiment, an LED calibration was also used to have a data set to compare to.

Some aspects of the broader motivation include hadron calorimetry for the Muon to Electron and the Light Dark Matter Experiment (LDMX) collaborations. The design of the detection apparatus is motivated by the hadronic veto calorimeter as described in the LDMX Proposal [1].

A silicon photomultiplier has many benefits over photomultiplier tubes. The primary benefits include linear gain, robust energy resolution, and compact sizes for easy use and portability [2], [3]. One disadvantage is that it has a smaller active area, limiting the amount of light it can detect.

2. Calibration and Experimental Methods

2.1. Calibration of a SiPM using an LED

The primary benefit of using an LED is that a scintillator is unnecessary in checking the response of the SiPM. For this reason, using an LED to make sure the SiPM works may be ideal before attaching and light-proofing the SiPM and scintillator. The primary downside of LED response is that it provides a much narrower response to photons based on the voltage applied using a function generator. This will be evident in the data analysis section of the report.

2.1.1. SiPM Configuration Parameters

Starting from the voltage sources, here is a list of the elements of the circuit and the rationale for each item:
1. HV Power Supply for the SiPM: This supplies the operating voltage of 26.5 V to the SiPM.

2. LV Power Supply for the Pre-Amplifier: This supplies 12 V to the pre-amplifier. The pre-amplifier acts to strengthen the signal to better differentiate the signal and noise by increasing overall gain.

3. 3 dB Attenuator: The attenuator acts to protect the electronics by reducing the gain of waveforms while not appreciably distorting waveforms.

4. Pulse Generator: The pulse generator has multiple purposes. The first purpose is to power the LED using a square pulse wave at an adjustable frequency. For the purposes of the calibration, I set the frequency to 1,000 Hz. The second purpose of the pulse generator is to act as a discriminator and coincidence control. That is, I can set another waveform to operate as a trigger for the signal generated by the LED, and then couple the two signals in the internal settings and manually shift the phase so they align. This would be analogous to adding length of physical wire to delay the signal.

5. Green LED: This color LED was chosen because it most closely matches the wavelength of the ideal wavelength shifting fiber. The operating voltage of the selected LED is roughly 1.8 V, and I have set the pulse generator to generate a square wave pulse with a height of 2 V.

2.2. Using $^{90}$Sr

Using $^{90}$Sr is optimal for detecting photons with the SiPM. The most apparent benefits are the broader range of photoelectrons and that the SiPM would be attached to the detector in the same configuration as the later Cosmic Ray Detection. A less apparent consequence is that the rate we can collect data is as much as 20 times that of the LED, where we are limited to around a kHz rate of pulses.

2.3. Error Propagation in SiPM Calibrations

In this experiment, we work with such high counts that it is sufficient to use $\sqrt{\text{Counts}}$ as the error determined for each Gaussian. I determined the total error to have an average of 13.5% with respect to the position of each
peak (for the LED). For the $^{90}$Sr this value was approximately 9.3%, which is expected as we had many more total counts using the source.

2.4. A Scintillator Based Detection Method

![Diagram of detection scheme]

Figure 1: Primary Detection Scheme: 1. An ionizing particle, such as beta radiation or cosmic ray muons will deposit energy into the scintillator. 2. The material reacts to the energy deposition and there is a burst of light (i.e. it scintillates). 3. The light travels randomly, but a piece of glass guides the light towards a SiPM detector. 4. Data is collected, usually with an oscilloscope or computer.

2.5. Detecting Cosmic Rays

In the experimental set up, the trigger pulse should be split and also sent to a counter. The counting rate is expected to be around 3-7 cosmic ray muons per minute. Therefore, if the counting rate is absurdly high, then we move the discrimination level up. The ideal experimental set-up for further research and development is illustrated in Figure 2.

![Image of experimental setup]

Figure 2: In this configuration we have two PMTs (on top and bottom) act as triggers for a scintillator with a wavelength shifting fiber embedded in its center coupled to a SiPM. In this particular case there was a SiPM on either end of the scintillator with green wavelength shifting fiber (of various diameters) on the inside of a plastic scintillator.
3. **Data Analysis and Results**

The data analyzed was collected during my WAVE Summer Research Fellowship at the California Institute of Technology. The experimental configuration is almost identical to Figure 2, except I used a dual-PMT triggering system on a dual-SiPM detection system. To accomplish the final goal of the experiment, I was able to determine the total number of photoelectrons for cosmic ray muons.

### 3.1. Calibrations

Figure 3 depicts the Gaussian fits of each photoelectron peak. Figure 4 then creates a linear fit based on each Gaussian fit. I was able to calculate a ratio of agreement of $1.04 \pm 0.10$ between the LED and $^{90}$Sr sources for the Hamamatsu SiPM A.

![Gaussian LED Fit](image)

*Figure 3: Illustration of Gaussian LED Fit: In this figure, I wrote a Python script to determine the location of each peak, plot each curve, and to then plot an underlying Gaussian that contributes to the irregularity of the curve. This data was taken from a Hamamatsu SiPM at the end of the summer and analyzed at the beginning of this semester to prepare for my change of SiPM types. Note: in the plot, the X-axis corresponds to the number of ADC channels (which is proportional to the pulse height and thus proportional to the energy) and the Y-axis corresponds to the number of counts. The error of the peak location is determined by the width of each Gaussian as determined by each plot approaching a Gaussian.*
Figure 4: Linearity of the SiPM: ADC vs Photoelectrons: Using the previously determined peak locations, I was able to plot the relative distance between peaks versus the Analog to Digital Channels. The slope of the line then becomes the calibration factor used in the later determination of average photoelectrons in various experiments for this particular SiPM.

Figure 5: Energy Spectrum of first several peaks for $^{90}$Sr: Where each peak after the second peak corresponds to the number of photoelectrons. The first peak represents the pedestal, which is an effect of the random triggering events. This particular data set comes from the "SiPM A"-Hammamatsu SiPM. In the Figure 6, we plotted the fit data similarly.

3.2. Cosmic Ray Data
Figure 6: This plot illustrates many important points. 1. There are many more points to have a better, and more reliable, calibration as opposed to the LED calibration. 2. Two SiPM’s of the same rated sensitivity may have different gains in a calibration and thus have different correction slopes. The uncertainty in the slope is listed in the conclusion.

Figure 7: Data from my SiPM A of a Cosmic Ray Muon. I found the number of average photoelectrons by fitting the plot with a gaussian and finding the average number of ADC. I then divided the average by the $^{90}\text{Sr}$ calibration constant.

4. Conclusion

We compared the calibration factor obtained based on a peak-height data collection method from an LED (515.8 ± 50.70) ADC Channels to a calibration factor obtained from $^{90}\text{Sr}$ (538.6 ± 43.22) ADC Channels. This gives a final ratio of agreement of 1.04 ± 10. Finally, I used the calibration constant
as determined from $^{90}$Sr to find the average number of photoelectrons of a cosmic ray source distribution to be (65 ± 6.9).

5. References


Impact of the Model Minority Stereotype and Lack of Social Capital Among Vietnamese American Students

Brooke Quach
The University of Texas at Austin
Stacey Lee, PhD, Faculty Mentor

Within the context of the Asian American community and the pervasive “model minority” stereotype, my project hopes to bring to light the struggles and experiences of first-generation Vietnamese Americans from the Houston area. Through structured interviews, this pilot study hopes to archive specific Asian American experiences that continue to defy and disprove the persistent “model minority” stereotype—the durable and racialized identity that generalizes the economic and academic success of all Asians in the United States. This study hopes to also archive the structural and systemic inequities that impose unacknowledged challenges upon students from lower socioeconomic backgrounds. Southeast Asian Americans who do not conform to such expectations are neglected in a system that claims post-racial meritocracy. While the aggregated data taken on Asian American populations in the United States obscures the problems and experiences of these specific ethnic groups, the individual narratives recorded through interviews will help illustrate a clearer portrait of the problems Vietnamese Americans face within the public education system. I use the theoretical lens of social capital to show how academic tracking and racialized identities affect the educational outcomes of first-generation Vietnamese American students. The findings of my study demonstrate that first-generation Vietnamese American students in the Houston area face several seemingly invisible problems emotional and financial burdens and unacknowledged mental health issues.

Keywords: Asian American, model minority, Vietnamese Americans, Southeast Asian Americans, social capital, tracking, Houston, first-generation, academic achievement.
Introduction

This study hopes to document how structures within the public education system affects the educational attainment of first-generation Vietnamese American students. Educational attainment can vary significantly among students, and a student’s social networks and resources can have a significant impact on whether they feel like they can attain a higher degree after high school. In other words, social capital and socioeconomic status can have a significantly impact an individual’s aspirations. In this study, I examine and investigate the educational attainment of Vietnamese American students and the obstacles they face in applying to and attending college. This attainment process includes the different variables that go into a student’s decision to pursue a higher degree after high school. Social capital plays a fundamental role in academic achievement and students of lower socioeconomic status must find different means to achieving “traditional” pathways of success (Palmer, R. T., & Maramba, D. C., 2015; Museus & Mueller, 2018). Lack of social capital compounded with a racialized identity sets first-generation Vietnamese American students in a unique and unacknowledged realm within educational spaces. While they are presumed to do well because of their racialized identities, educational attainment or the lack thereof reflects a problem that goes unacknowledged and unseen. My project will investigate educational attainment and the relationship between effort, achievement, racialized identities, and tracking. My research questions are: What obstacles do Vietnamese American students experience during their time in high school and how do these experiences affect their post-secondary educational career? What affect does social capital have on academic achievement, persistence, and aspirations?

My main methodology will consist of interviews. My qualitative interviews will be framed by a specific set of questions approved by Dr. Stacey Lee. I hypothesize that social capital will play a significant role in educational attainment. Dr. Lee and I discussed the importance of recording how one felt in specific situations and stimuli (e.g. one’s attitude towards school, teachers, peers, etc.) to demonstrate how structural and systemic phenomena can affect effort. We also discussed how one’s knowledge base and potential success was affected by their social networks and capital. In a meritocratic culture that blames students of color for not achieving a traditional mode of success because they did not appear to “work hard enough,” the model minority narrative also glazes over students who don’t meet traditional standards of success.

Methods

This project is a qualitative study on Vietnamese Americans. I interviewed five peers over Facetime or Skype to discuss their careers after graduating from high school. Aside from Tuan, four out of five participants are second generation Vietnamese Americans. All participants are 19-23-year-old Vietnamese Americans. The pool also includes individuals who are first generation college students and individuals who didn’t pursue post-secondary education. I connected with these participants by contacting other mutual friends, but I personally know all these participants as they went to school with me at some point during my own career. Participants were chosen knowing that they were first-generation college students or would have been first-generation if they pursued a post-secondary education. Although this is a heavily biased and skewed set of participants, I believe that the qualitative nature of this project is not undermined. As a pilot project, this set of participants helps illuminate problems affecting Vietnamese Americans in the field of education. The individual narratives and stories each
participant share another aspect within the multi-dimensional problem affecting disadvantaged minorities.

Each participant was interviewed separately, and each answered a set of semi-structured questions to investigate the factors that allow/ disallow a student from pursuing a higher education. I would call participants over Facebook video and initiate the interview after introducing my project. Before the interview began, I also acknowledged that this article will not be published and that their identities will be changed. I also primed the interview as “conversational” in tone and nature in order to communicate that this interview was not making any judgement about their personal choices.

**Interview Questions:**

I created these questions based upon my own research inquiries. The interview questions explored each participant’s relationship with school and the obstacles they faced when applying for college. The questions were chosen and written to illustrate a more holistic story and narrative that quantitative data is unable to show. I designed the interview protocol with input from Dr. Stacey Lee to identify specific identity markers such as income and first-generation status and to explore aspects of each individual’s racial identity. As is typical of semi-structured interviews, the interviews often strayed from just these questions. Because of my personal relationships with the participants, they felt freer to disclose extremely intimate aspects of their academic journeys. The interview protocol is at the end of the paper (appendix A).
Literature Review

The Houston Vietnamese American Population

The cause for the Vietnamese diaspora is attributed to America’s loss at the end of the Vietnam War. After the Northern Vietnamese communist party, or the Viet Cong and People’s Army of Vietnam captured Saigon, many South Vietnamese loyalists were subjected to displacement, punishment, and imprisonment (Rkasnuam & Batalova, 2014). To avoid the political repercussions of persecution, displacement, and governmental instability under the communist regime, these Southern Vietnamese populations and loyalists sought asylum in Western countries such as Australia, Canada, France, and other parts of Europe (Rkasnuam & Batalova, 2014). The largest population of Southern Vietnamese came to America, and historians identify that the immigration came in three distinct waves (Rkasnuam & Batalova, 2014).

According to the Migration Policy Institute, the three distinct waves can be defined by social class and educational attainment (Rkasnuam & Batalova, 2014; Alperin, E., & Batalova, J., 2018; Museus & Mueller, 2018). At the Fall of Saigon in the beginning of 1975, the first wave came to America. This wave consisted of highly educated individuals from higher social ranks, particularly military personnel; these refugees were at a higher risk to be prisoners and targets of Vietnam’s communist regime. Because this group of refugees were considerably more educated, they also had more transferable skills in America, making their transition into America’s workforce smoother.

In contrast, the second wave of Vietnamese refugees faced many more hardships. The second wave of the late 1970s consisted of less educated individuals from rural backgrounds. The second wave was also known as the “boat people” because of the precariously small boats these refugees fled from Vietnam on towards refugee camps for days, weeks, or months. These people of these boats were vulnerable to pirates, overcrowding, and the piercing, inescapable heat and elements of the Pacific—countless died on the perilous journey due to these harsh conditions. Second wave refugees desperately escaped displacement and endured a traumatic journey to come to America without many transferable skills. Their transition into American workforce and society was rougher. Many working-class Vietnamese people within the Houston area are second wave refugees (Kriel, 2016). The third wave consisted of immigrants coming to America in the late 80s and 90s. Many of them were Amerasians, or children of American servicemen and Vietnamese mothers and political prisoners.

As of today, there are more than two million people of Vietnamese descent residing in America and more than 120,000 residing in the greater Houston area (Alperin & Batalova, 2018). The Houston community also has the third largest Vietnamese population in the nation and their cultural presence is demonstrated through the prevalent food markets, small businesses and shops, and restaurants that dominate the strip mall plazas on Saigon/ Bellaire Boulevard. Houston is a metropolitan area filled with multicultural hubs. The majority of Asian Americans in Houston are foreign born; about 71% were born in another country (Binkovitz, 2016). Houston is the fourth largest city in the U.S. and is home to an extremely large and prominent Asian American community— which is its fastest growing group (Binkovitz, 2016).

Asian Americans within the Houston area have experienced tremendous growth within the last decade. Houston is also an extremely large and robust area with several different districts. Between 2000 and 2010, Harris County’s Vietnamese population grew by 45% and it stands as the largest Asian ethnic group within the county. Roughly 31% of all Asians in Harris County
are of Vietnamese descent, making them a significant and influential community in the Houston area (Binkovitz, 2016). Although Harris County’s Vietnamese population is extremely large, and its voices are heard through HISD’s Asian Advisory Committee, it’s suburban neighbor Sugar Land, does not have as large of a population (Chen 2018). While Sugar Land is 37.5% Asian, the Vietnamese community only makes up 15% of that portion (Klineberg & Wu, 2013). Because the Vietnamese are a small minority in Sugar Land, their voices aren’t as heard and their presence is not reflected like it is in HISD, where they have an Asian Advisory Committee to ensure immigrant voices are heard (Chen 2018).

**Model Minority Stereotype**

In order to understand the model minority myth, it must be placed in the context of Other political structures concerning class and racial histories (Lee, S. J., 2009; Ngo B. & Lee, S., 2007). The model minority stereotype assumes that all Asians are high-achieving, well-behaved, and apolitically submissive. The durable stereotype is often used in contemporary conversation to justify that all minorities can succeed and prosper in America. Although some may perceive a stereotype defined by the generalized success and achievements of a racial group as a positive attribute, the stereotype neglects specific ethnic communities who are not performing as well. The stereotype is also intended to make other minority groups appear culturally deficient (Lee, S. J., 2009; Ngo B. & Lee, S., 2007). The “model minority” myth, which erases the complex experiences of different ethnicities within the AAPI community, is still reinforced through public school systems (Lee, S. J., 2005; Ngo B. & Lee, S., 2007). Several scholars also advocate for disaggregated data on local, state, and national levels and to train more AAPI teachers in order to serve the AAPI population better (Lee, S. J. & Kumashiro, K., 2005; Ngo B. & Lee, S., 2007; Ramakrishnan, K., & Ahmad, F., 2014). The aggregated data hides particular Asian ethnic groups that do not perform as well as other financially established Asian ethnic groups, such as Chinese Americans and Japanese Americans.

This myth perpetuates the disenfranchisement of many Southeast Asian refugee groups that do not achieve the same amount of educational success as other ethnic groups within the racial category of “Asian American.” The model minority myth is a political weapon against other minority groups, it suggests that all AAPI have overcome racial barriers to success. By citing the success of financially established ethnic groups (e.g. Chinese and Japanese Americans), the stereotype dismisses cases of racial inequality affecting all Asian Americans (Lee, S. J. & Kumashiro, K., 2005). Social class plays a significant role in educational attainment, and although it is more probable for Asian Americans to earn more than $75,000 than it is for white people, it is also more probable for them to earn less than $25,000 in a year than it is for white people (Lee, S. J. & Kumashiro, K., 2005). The model minority myth obscures the latter statistic, rendering lower-income Asian American communities invisible. Southeast Asian communities make up a large portion of the less traditionally successful Asian American communities (Yang, K., 2004).

When viewing the AAPI community, focusing on the disaggregated data is fundamental to understanding the achievement, wealth, and health gaps and disparities between the different ethnic groups encompassed by the racial label “Asian American” (Ngo B. & Lee, S., 2007; Yang, K., 2004; Ramakrishnan, K., & Ahmad, F., 2014). Because Asian Americans are made up of numerous different ethnic groups with numerous different histories, each ethnic group’s experience will also differ. Considering the historical migration patterns of Vietnamese people to America, their experiences will be incredibly different from third generation Chinese, Korean, or Japanese Americans. Southeast Asian Americans, which includes Vietnamese, Laotian, Hmong,
and Cambodian people, are struggling academically and economically (Palmer, R. T., & Maramba, D. C., 2015; Museus & Mueller, 2018). While 28% of the general American population holds a four-year degree, 26% of Vietnamese, 14% of Hmong, 13% of Cambodian, and 12% of Laotian Americans hold one (Museus & Mueller, 2018). These Southeast Asian American groups also live in disproportionate poverty rates compared to other AAPI groups. While 9.7% of Japanese and 9.8% of Asian Indians live in poverty, 16.6% of Vietnamese, 37.8% of Hmong, 18.5% of Laotians, and 29.3% of Cambodians live in poverty (National Commission on Asian American and Pacific Islander Research in Education, 2008).

KaYing Yang discusses the specific obstacles that Southeast Asian Americans face within the public education system. While families are supportive in terms of higher educational attainment, SEAA families face “limited English skills, discrimination, systematic miscommunication between students, parents, and teachers, and widespread feelings of alienation” from the schools they attend (Yang, K., 2004). The English language barrier is one of the most significant obstacles facing Southeast Asian American families, particularly the Vietnamese American population. According to the Center for American Progress, 34% of Vietnamese households in the U.S. are linguistically isolated (Ramakrishnan & Ahmad, 2014). Many Vietnamese American refugees still suffer from their traumatic experiences of escaping Vietnam and many never learned English. Teachers who reinforce an “American” culture in which they expect parents to reach out to them about problems, but parents who are not fluent in English are oftentimes too shy to reach out to school administration and staff (Yang, K., 2004). Vietnamese American linguistic isolation can also speak to the working-class jobs and the effect that has on Vietnamese American parental involvement. Incomes, job mobility, the quality of health care are also heavily linked to English proficiency (Ramakrishnan & Ahmad, 2014).

Negative stereotypes also cause teachers to see SEAA students as poor prospects— they are not a population to invest in because they are aligned with delinquency, gang membership, and other fear evoking stereotypes (Yang, K., 2004, Lee, S., 2001). Lee’s (2005) book on the educational experiences of Hmong American students in Wisconsin, many of whom have fallen through the cracks. Teachers valued White, middle-class norms and values, which the Hmong population does not reflect. Lee identifies the racialized paradigm in which the Hmong population was seen through—the traditional (who were predominately ESL students) and the “Americanized” (who predominately took mainstream courses). While the traditional group were found ways to preserve their cultural identities are seen as “good” kids, Americanized Hmong adopted a counter youth culture associated with truancy, delinquency, and gang membership. Americanized Hmong behaviors and counterculture reflect intergenerational tensions and a school system that does not accommodate or acknowledge cultural or racial tensions (Lee, S., 2001). These misconceptions can further the neglect and dismiss the complex obstacles that Southeast Asian American youth face in unaccommodating school environments.

Social Capital & Tracking

Zhou and Bankston argue that the implications and social capital in being a member of the ethnic Vietnamese community is a large cause for success for Vietnamese American students (Zhou, M., & Bankston, C., 1998). In their study, Vietnamese American student success and socioeconomic advancement depended heavily on the support and control enforced by networks of social relations. Support and control stems from the “respect” and affirmation of authority figures, immersive and constant ethnic involvement on economic, religious and psychological
levels, and a system of norms and values associated with constructive behaviors. Positive outcomes seem to derive from the patterns of social capital that exist within the Versailles Village community and how these patterns of social relations harmonize with America’s contemporary social structure. On the other hand, non-conforming identities are ostracized and condemned. In the context of Vietnamese Americans who do and do not achieve mainstream success within the context of the model minority myth, my project hopes to analyze Vietnamese Americans who do not live up to the model minority achievement stereotype.

According to Bourdieu (1986) the term, “social capital” is defined as “the aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition—or in other words, to membership in a group.” Social capital can be defined as the collection of social networks, connections, and knowledge bases an individual can access (Lan, N., 1999; Museus, S. D. & Mueller, M. K., 2018; Palmer, R. T., & Maramba, D. C., 2015). Social capital is not just a matter of simply having these networks and connections, but knowing how to use them in order to advance in society (Palmer, R. T., & Maramba, D. C., 2015). Palmer and Maramba’s study found that care agents such as counselors, relatives, and supportive teachers were paramount to Southeast Asian American student success and application to colleges and universities (Palmer, R. T., & Maramba, D. C., 2015). These “care agents” served as institutional agents that linked individuals to otherwise inaccessible knowledge bases and networks, thus acting as a form of social capital. Organizations, pre-college programs, and specific student services were also responsible for application success amongst first and second generation SEAA. The cultural capital of our nation’s schools is governed by whitestream, middle class values, which can systemically exclude students of color from low-income backgrounds, e.g. Southeast Asian Americans (Museus, S. D. & Mueller, M. K., 2018; Lee, S., 2006). The organization of schools and tracking is directly intertwined with social capital in many ways.

Academic or curricular tracking is “a social structure” that assigns students to certain academic classes based upon overall achievement (Carbonaro, W., 2005). Because students are placed on different tracks that offer different academic opportunities, tracks create and reproduce inequities within the educational system (Ochoa, G., 2013; Carbonaro, 2005; Oakes, J., 1985). Different classes provide different and even limited opportunities for learning, thus affecting what a student could and should learn (Carbonaro, W., 2005; Oakes, J., 1985). For example, if a student is encouraged to take pre-AP/ AP classes in high school, they are prepared to take those respective AP tests. These students gain a skillset in studying for more rigorous tests and a more challenging curriculum. They can also gain a form of financial capital by scoring well on AP tests, as these scores can translate into college credit. Students who remain on non-AP or non IB tracks do not gain these study skillsets, nor are they taught at the same pace or curriculum as AP or IB students. Simultaneously, they are denied access to the financial capital that AP tests provide. The results of Carbonaro’s study on tracking suggest that we should not assign blame on students, but rather, we should evaluate the class environment that appears to be discouraging students from exerting effort and instead, cultivate an environment that challenges and stimulates (Carbonaro, W., 2005).

Tracking reproduces social inequities by placing different “types” of students on different pathways. It also disproportionately affects low-income students of color (Ochoa, G., 2013; Oakes, J., 1985). In her book, Academic Profiling, Ochoa investigates the systemic structures that create and reproduces racialized and classist inequities in a racially mixed school comprised of Asian and Latinx students. In her study, she found that tracking excludes poor Latinx and
Asian populations and reproduces students who are probably unprepared for a higher education. Tracking can also be interpreted as a form of racial and classist segregation (Ochoa, G., 2013; Oakes, J., 1985). When students of color from low-income backgrounds are funneled into lower tracks, they are fundamentally given less opportunities to succeed. Their social capital and networks are limited to the tracks they are funneled into. They also engage in less stimulating environments and are not held to the same standards as higher track peers (Carbonaro, W., 2005). This inequity within the school’s organizational structure translates into inequities post-graduation, as lower track students with less opportunities and knowledge bases are expected to compete against their peers who have accumulated greater social capital. While schools give students the autonomy to choose their tracks, choices can be limited. In schools with lower-income racially isolated communities, lower-level classes outweigh higher level classes due to funding and resource distribution (Oakes, J., 1985). Even in schools that are racially mixed, lower-income students of color are still tracked into lower-level classes (Ochoa, G., 2013; Oakes, J., 1985).

### Results

<table>
<thead>
<tr>
<th>Name</th>
<th>Age</th>
<th>Current Occupation</th>
<th>First Generation Status/ Highest</th>
<th>Reduced Lunch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michelle Nguyen</td>
<td>19</td>
<td>Barista, CC</td>
<td>First Generation college student at Community College</td>
<td>Y</td>
</tr>
<tr>
<td>Gwen Nguyen</td>
<td>21</td>
<td>Unemployed</td>
<td>Parents did not go to college</td>
<td>Y</td>
</tr>
<tr>
<td>Tuan Duong</td>
<td>21</td>
<td>Unemployed</td>
<td>Parents did not go to college</td>
<td>Y</td>
</tr>
<tr>
<td>Vincent Le</td>
<td>23</td>
<td>Marine Corps</td>
<td>Parents did not go to college</td>
<td>Y</td>
</tr>
<tr>
<td>Jonathan Tran</td>
<td>21</td>
<td>UT Student</td>
<td>First Generation college student at UT Austin</td>
<td>Y</td>
</tr>
</tbody>
</table>

Participant and smaller school names have been changed. All participants, aside from Tuan, are second generation Vietnamese Americans. Out of the five participants, only one (Jonathan Tran) attended a four-year university. Michelle Nguyen is currently attending Bartone County Community College and is planning to transfer to Texas Women’s to pursue a degree in Nursing. Vincent is planning to attend UT Austin spring 2020. Although both Tuan and Gwen expressed a desire to attend college in the future, they have not set a specific date or plan due to a variety of obstacles.

Financial obstacles and lack of social capital was the most persistent problem and factor that determined whether a student pursued a higher degree. Many participants felt limited and constrained by personal issues such as abusive relationships, divorce, drug addiction, and other mental health issues. In a system where these personal issues stray from what is conceived of as normative, first generation, low income students face these problems alone. Many first-generation students come from low-income backgrounds, and all the participants disclosed that they were on free/ reduced lunch at one point in their lives. I classify these recurring problems and conflicts into several different categories/ themes.
While analyzing the interviews collected at the beginning of July 2019, I noticed three apparent themes throughout the five transcriptions: 1) Financial Burden, 2) Mental Health as a Taboo, 3) Esteem/ Merit/ Model Minority. The most apparent theme was the financial obstacle of attending a four-year university straight out of college. All participants cited a financial obstacle in pursuing a four-year degree. The word, “burden” came up often during interviews and the concept appeared to be intertwined with the individualistic outlook on achieving merit many participants held. This outlook can be identified as having to do everything for themselves by themselves. A theme that intertwined with the ideas of “burden” was a low-esteem when it came to talking about their effort during their time in school. Another trend that I noticed was the lack of conversation revolving around mental health within the Asian American community, specifically the Vietnamese American community. Three out of five participants cited some emotional or mental strain that stood as an obstacle during their time in high school and post-graduation. These specific strains were intense amounts of stress, toxic relationships, and drug abuse—all of which had a negative impact in their decisions to not pursue a higher education. Not having health insurance, lack of support/acknowledgement from family and community members disallowed any avenue of discourse in navigating these “invisible” issues. Michelle, Gwen, and Tuan all cited that they felt that they did not have adult mentors who could help or advise them when they applied for college. They described their lack of trust for adult figures and sincerely thought they were supposed to do everything by themselves.

Financial burdens, the lack of discourse concerning mental health, and the effects of the model minority stereotype are all linked to a lack of social capital. This lack of social capital compounds the financial burdens, racialized identities, and mental health issues Vietnamese Americans experienced during their time at school. When any one of these students struggled, each student assumed that was how the system was meant to be. As low-income Vietnamese students whose parents did not attend college, this mentality and approach to navigating a school system that favors students from more privileged backgrounds, disallows mistakes and compounds personal hardships. These next few pages will discuss participants’ narratives in order to illustrate the multi-dimensional problems affecting first-generation Vietnamese students.

1) Burden

A burden of guilt and finance seems to stem from Vietnamese American history and the culture of work connected to it. The immigrant narrative in which one’s parents has lifted themselves by their bootstraps and that they work hard for their children’s benefits is a common one within the Vietnamese American community. Many Vietnamese immigrants live working class lives; many work more than ten hours a day to provide for their children (Zhou, M., & Bankston, C., 1998). All participants cited that their parents worked at least one, sometimes two, jobs at a time, making them absent from most of their academic careers.

This immense sacrifice amongst the Vietnamese American community imposes a sociocultural norm on young Vietnamese Americans to succeed. As Vincent said in his interview:
“... My mom was a little bit more on the… on the like… heavier side, when she was saying what she was saying. You know like, it was a pressure of like: ‘Hey, I came to this country to have a better life, so you would have a better life.’ And I’m not going to say all but a majority of Asian—first-generation Asian culture— their parents came to this country to work hard, so that their kids could have a better opportunity, which is true um but— and they only see education as
the way to a better opportunity— in the way where they’re like more so as like: ‘You have an education, you get a degree, you do this, you won’t have to work as hard as I do.’ And it comes from a good place. It comes from a place where they want their child to be successful, where they’re not struggling as much as they did coming up. In high school I had already thought about it, and I saw what it actually took to you know be successful, whatever, in whatever way you think being successful is— and in any path to be successful, there is hard work involved. That aspect of hard work never disappears. And I wouldn’t say that they don’t understand that but like to a certain extent they don’t.”

Here, Vincent refers to the physical, mental, and emotional toil that the Vietnamese immigrant experiences. The pressure to alleviate one’s parents from working away their entire lives is imposed on children, and school is seen as one of the most viable and respectable options. Academic achievement is reduced to the only route towards a life where one is not constantly toiling in a service job that does not fulfill, create, or give purpose. Vincent also speaks to the meritocratic culture attached to the Asian American immigration narrative, where one is obligated to work hard to ensure parental sacrifices do not go to waste. This immigrant narrative places an emotional burden on students who do not achieve their parent’s expectations.

The obligation to achieve and bring one’s family out of the working class can be interpreted by children in many ways, but it ultimately places a heavy pressure on students who may not have the resources or social capital to do so. No matter how hard a student works, not having access to resources can block a student from achieving their dreams. In conversation with Vincent’s anecdote above, Tuan seemed to view his effort as inferior or “not as serious as [it] should be.” Not being able to achieve a specific standard, i.e., taking the four-year route, Tuan states that an investment in a four-year education seems futile and not valuable.

“Brooke: And your parents were able to afford it?
Tuan: Yeah, they would be able to afford it, but like all the other miscellaneous things are preventing me from doing it.
Brooke: What miscellaneous things?
Tuan: Just commuting, and moving out of the house, and renting an apartment just to go to school and stuff.
Brooke: Is that scary to you or?
Tuan: Not scary… just like… I don’t want to use so much funds or burden my parents even more. Especially when I’m not as serious as I should be in education.
Brooke: I mean it’s pretty serious, you’re taking your school very seriously. An education just shouldn’t cost that much I feel. It shouldn’t be a burden to anybody.
Tuan: Yeah well it is.”

Within the past few years, the price of a higher education has soared to nearly impossible prices for lower-income students, systematically denying them direct access to higher institutions. While lower-income students can take out loans and receive grants, debt from other incurring costs (e.g. housing, books, and commuting) and the risk of pursuing a higher degree can be a significant deterrent. Debt and risk compounded by no mentorship can make obtaining a higher degree feel like a bad investment. In Tuan’s case, he also interpreted his own efforts as “not as serious as [he] should be,” despite his constant descriptions of the time, effort, and work he put into school. This distortion of how he views his effort and the uncertainty of financial instability can also make education appear as not worth it or futile.

As Tuan puts it:
Brooke: So at the end of high school did you want to go to college?
Tuan: Yeah, I did, but I didn't know which one, and I didn't know whether I wanted to pay for a higher institution instead of community college. And I didn't know if I should go from community college to just going into the work and try to make as much money, to gain the capital, to trade.

Brooke: What deferred you from pursuing a higher—?

Tuan: The cost I guess. The fact that I had to commute all the way to a higher— just take UH for example, it would take anywhere from 45 to an hour just to get there, so I didn't want to make that investment.

Tuan is not alone in his decision to not attend a four-year institution. All participants in the study cited that although going to college was a priority for their family, it placed an absurd financial burden on the family. Even for participants who disclosed that their family could have paid for college, participants felt that their dream would still place a burden of immense guilt on themselves if they pursued their ideal routes.

In her interview, Michelle Nguyen opened up about her personal and familial circumstances:

Brooke: Did you ever feel like your home life every bled into your school life? Or that it added stress into your school life?

Michelle: [pause] A little bit... a little bit. Because most students work, so they have to balance that work and school life, and like, you know like, you know that my parents are divorced right? And you know that plays a large part of it. In that time, late middle school and early high school, was when they were processing the divorce, and Kyla (Michelle’s younger sister) was young and she didn’t know, or at least she didn’t like understand… it was a lot to take in... to adjust and change lifestyles.

Brooke: How did your lifestyle change?

Michelle: It was more of a struggle financially… that was the biggest thing. It was just my mom… and Gwen (Michelle’s older sister) and I couldn’t drive until we were 18… and then Gwen was like rebelling at the time. She was supposed to be the oldest and like the role model, you know what I mean? So I had to step up and grow up fast to help my mom and take care of Kyla and work and school… It was just a lot of pressure.

The pressure described by Michelle in this interview was a burden placed on Michelle during some of her most crucial years of academic development. Later in her interview, Michelle stated that she was unable to take more AP classes due to stress. The adjustment in lifestyles between a two-parent household to a single parent household with half the income became an additional struggle for Michelle during her time at school. This struggle was compounded by other familial hardships that burdened Michelle’s performance in school. Michelle’s anecdote demonstrates that financial burdens can indirectly impact a student’s mental health and social capital. Because Michelle couldn’t take more AP classes, she, in theory, was exposed to less opportunities and knowledge bases than other peers who took more AP classes.

If we compare the academic journeys of Jonathan Tran, who currently attends UT Austin to Tuan Tran, who dropped out of community college, the differences in resources are extremely apparent. When I asked Jonathan about the resources available to him at his magnet high school, he was able to single out specific mentors and programs that helped him succeed:

Brooke: Can you describe the resources that helped you apply to college?

We had- so off the top of my head, Kett HS was really good with dual credit. We had a ton of dual credit classes and like partnering with community colleges like HCC and I think maybe Lonestar helped us out a bit? UH had some classes as well for us, um and so that gave us a
jumpstart with college credits. Our counselors had mandatory— I think it was mandatory— we had to go talk to them just about our colleges, the options we had or were considering. We also had a college career readiness center and their job was to help us with applications again with those dual credit classes, and just mentoring us about how the whole process looks like and what we should be looking forward to.

When I asked Tuan about these resources, I received an extremely different answer:
Brooke: Did anybody help you with applying to college?
Tuan: I forgot her name… the black lady next to Mr. Delta. Yeah, she did, but she didn’t help as much as I thought. Like I found a way to fill out my applications for community college, but I didn't like, but I didn’t understand how I was supposed to transfer after that… I didn’t know what to do after that.
Brooke: She helped you with FAFSA then? She was only one woman yeah, I remember that…
Tuan: Yeah and there were like 30 kids coming in. It was like really a constraint on time... a tension.
Brooke: Did you ever think of somebody as somebody who could get you into [a four year] college? Besides the college advisor?
Tuan: Nope, I only went to her… so I guess it was a fault of mine.

Jonathan and Tuan went to two different high schools within the Houston- Sugar Land area. While Jonathan attended Kett High School, where the Vietnamese population has a greater voice in the educational system, Tuan attended Geyser High School in Sugar Land, where the Vietnamese population makes up a small minority of the Asian population. Although they live about ten minutes away from one another, the distribution of college access resources between the two students’ schools had a significant impact on their academic achievement. While Jonathan went on to UT Austin, Texas’ premier state school, Tuan dropped out of community college. The burden of achieving “less” is also evident in Tuan’s self-blaming rhetoric stating: “Nope, I only went to her… so I guess it was a fault of mine.” Despite visiting and engaging with the main college access resource at his school, Tuan still felt like it was his fault for not achieving more. There is an acknowledgement that the academic advisor was overloaded with kids to help, yet Tuan still pays an emotional burden. The financial burdens that place enormous amounts of pressure on Vietnamese American students as they pursue their dreams can translate into guilt and shame when those goals are unachieved.

2) On Mental Health as Taboo

Although mental health was not a direct issue I addressed through my questions, it became increasingly clear throughout the interviews that mental health issues were stigmatized and undiscussed. Out of five participants, three of them cited extreme amounts of stress, ADHD, abusive relationships, drug addictions, and familial instability. The model minority stereotype and the ideas of achievement attached to the stereotype obscures the prevalence of mental health issues. In Tuan’s case, viewing mental illness as an individual deficiency also disallows any conversation related to mental illness. Mental health issues remain unseen because it does not align with the mythical and smooth success of Asian Americans.

Tuan spoke about his ADHD diagnosis at the beginning of his high school career:
Brooke: How was your relationship with high school versus college?
Tuan: Beginning of my high school years, I was— I didn’t really care about school that much. I was on the basketball team, so I was focusing on that, but I almost failed one of my classes and I
got diagnosed [with] ADHD around the end of 9th grade. And I didn’t start medication until like the end of 10th grade. Until then, I just took like therapy and stuff to help manage my ADHD. And around 11th grade to 12th grade, I started to take school more seriously… I started to take more AP classes. And from then there on, I just tried to get to the best college I could. I guess I kind of strayed from that.

While Tuan was diagnosed for his ADHD, it wasn’t until the end of 10th grade where he started to take Adderall. Even after being diagnosed, Tuan still did not feel comfortable with telling anybody about his condition. ADHD is a condition that can make it impossible for somebody to focus and it can adversely affect their productivity and schoolwork (“NIMH »ADHD: The Basics,” 2019). It is also important to note that Tuan was also on a regular track up until 11th and 12th grade. Despite these effects, Tuan felt that his ADHD was something he had to get through alone:

Brooke: Did you feel like you were being helped? Did your teachers even acknowledge that you had ADHD?
Tuan: I actually didn’t tell them. So I just worked with it… without them knowing.
Brooke: Why not?
Tuan: I don’t know, I just didn’t want to take the effort to like make them know that I was inferior in some way… you know?"
Because having ADHD strays from normativity, it carries a negative stigma and it can be wrongfully internalized as a deficiency. In Tuan’s case, he appears to believe that ADHD made him “inferior in some way.” Tuan viewed it as something shameful, so he endured the problems caused by ADHD alone rather than asking his teachers for help or accommodations.

Aside from his ADHD, Tuan also chose to disclose the unhealthy relationship he developed with school and his consequential drug addiction:
Tuan: I [would] just stick to thinking about when I was happy when I wasn’t taking any drug most days to keep myself from taking any drugs (aside from smoking cigs). I can’t pinpoint the exact time when I fell into the habit, but it definitely started with me being obsessed to keep up with the top of my high school classmates. Starting around the middle of the 11th grade, if I didn’t get the top score, I’d get angry at myself for not pushing myself harder to achieve the best possible grade to the point I’d self-harm just to “motivate” myself to do better since I knew I was well behind... I started to realize how far behind I was and I just continued pushing myself further via amphetamine (Adderall) & cocaine to get the results I wanted. It continued throughout my senior year since I took all AP classes then and all my peers were smarter and younger. Eventually I just burnt out.
Although I am not qualified to diagnose Tuan in any way, the way in which Tuan saw his achievements is objectively not healthy. The compounding pressures placed on achievement in the context of Tuan’s ADHD demonstrates a need for more resources and outreach for people like Tuan.

Another family that cited mental illness were the two sisters, Michelle and Gwen. Because Michelle and Gwen’s family do not have a health insurance plan, they do not visit the doctor, nor have they ever been diagnosed with any mental health issue. Michelle cited issues of extreme stress and Gwen stated that she was unable to focus on any of her assignments or studies. Despite wanting to reach out to a professional for help, Gwen felt financially unable and accepted that she would have to work around her inability to focus by herself when it came to her studies. Gwen also talked about her mother, who recently lost her job in the wholesale industry:
Gwen: “Yeah and now… she [Gwen’s mother] only works [at the nail salon] only on the weekends. But on the weekdays, she has Kyla most of the day. And most of the day, she’ll be in her room doing karaoke to make the stress away. She’ll sit there for hours, dude.”

Although I’m unqualified to diagnose any of these issues, the behaviors and hardships cited seem to qualify more inquiry on mental health resources. Not having insurance that can give access to such resources worsens the impact of these issues, making it a systematic problem related to social and financial capital. When working class people are unable to access resources concerning conditions that largely affect them, such as going to the doctor to be diagnosed for mental illness, these problems are not classified as problems. These problems will remain invisible in Asian American communities for as long as they remain unaddressed. Mental health issues can be crippling and disabling, but with proper treatment, education, and discourse surrounding the issue within the Asian American community, its effects can possibly be minimized.

3) Model Minority Myth

The model minority myth generalizes and obscures the systemic and racial obstacles that first-generation Asian Americans confront during their education. The pressure of achievement can also become compounded by personal, familial, and financial hardships. In Michelle’s case, her social networks misinformed her about the meritocratic structures of the college application process. She ultimately seems to blame herself for not achieving more, despite the stress of being raised by a single mother in a low-income household:

Michelle: “I could have done better… because everybody was like once you’re in college, everything you’ve done in high school won’t matter. Like grade-wise and all that stuff like SAT scores… all that won’t matter once you get into college. So, I just thought, as long as I meet the requirements to get into college, I’m good! So there’s no need to go above and beyond to get that high score… but I should have! Because then I could have gotten into a better college and stuff… Yeah that’s the only thing, I could have done better. I’ve taken AP classes and stuff and I could have done better if I really tried, you know? Because I’m not really book-smart, and if I wanted to get a good grade and a high rank, I would have to like… really try. But a lot of people at Kempner are just like naturally gifted and they’re like just super smart so…”

Lee and Zhou write about the very “achievement paradox” Michelle is referring to in the Asian American Achievement Paradox; while Michelle has internalized a growth mindset by saying she should have tried harder, she applies a fixed mindset to her peers by describing them as “naturally gifted… [and] super smart” (Lee, J. & Zhou, M., 2015). When Michelle was faced with the numerous hardships that she could not handle by herself, these two mindsets on achievement clashed. By her logic, higher achieving students achieved more because of sheer intelligence. Michelle seemed to believe that if she tried harder, she could have achieved the same. The result appears to be self-blame and a sort of embarrassment for not “try[ing] harder,” even when faced with her individual hardships. The two different mindsets mutate into a perception that blames her lack of effort, rather than her lack of social and financial capital.

Despite her adverse circumstances, Michelle plans to get her bachelor’s degree in Nursing. Although Michelle had no control over the factors that put her at a disadvantage, Michelle used a self-blaming rhetoric to place a significant amount of the blame upon herself throughout her interview. Meeting the expectations for academic achievement or attending a four-year university becomes an impossible task when one’s hierarchy of needs are not being
met at home. Michelle also expresses a meritocratic and individualistic outlook on how she could have achieved more if only she had “tried harder.” In a system where Michelle was not given the resources to go directly to a four-year university, this growth mindset can only go so far. These instances of self-blame are also compounded by thoughts of low esteem. These interviews further demonstrate that social and financial capital greatly impacts student achievement.

While the model minority myth expects all Asian Americans to do well, many first-generation Vietnamese Americans lack the social capital to reach that expectation. Much like Michelle’s clashing mindset concerning her peers and her own achievements, Tuan described his mother’s expectations and how no amount of effort could get him to that standard:

Tuan: “Yeah at the end, she guessed I wasn’t going to be at the front of the line [magna cum laude]. I was ranked in the 400s beginning of my 11th grade year & only managed to jump to 245 by the 2nd semester of 12th. She was just expecting me to graduate, I guess. I mean, I don’t want to say it, but it made me complacent and just made me give up, but it kind of did. Because by the end of 12th grade, I mean I wasn’t doing my homework or doing well on any of the tests or anything. I just kind of gave up. I didn’t see any reason for why I should push forward. I guess I just wanted to wait until I found something that I really wanted to do....”

Tuan remained on a regular track up until 11th grade after he began treatment for his ADHD at the end of 10th grade. By taking the regular track for half of high school with untreated ADHD, the two factors relegated him to the lower half of Geyser’s class of 2016. No matter how many A’s Tuan made in his AP classes, there were many other students who took more AP classes, and therefore had a higher ranking. Tuan’s mother set an impossible standard and as cited above, Tuan exerted an unhealthy amount of effort, resorting to drugs to stimulate his academic performance. His achievement is based on external performance markers such as rank and grades, mitigating and undermining the holistic obstacles Tuan confronted throughout high school. The stereotype obscures these obstacles, making them appear illegitimate to the victim of inequities.
Discussion

In this study, I investigated the effect of social capital, the model minority stereotype, and tracking on Vietnamese American academic achievement. I replaced all the names of the participants and all schools with pseudonyms. Although the results of my study significantly align with the current literature we have on Asian Americans, my results also raise many different problems and concerns pertaining to the Vietnamese American community in the Houston area. The results of this study confirm that social capital, tracking, and the model minority stereotype play powerful roles in the academic achievement of Vietnamese American students.

The results of my study indicate that Vietnamese Americans face three distinct issues in their pathways towards academic achievement. Tracking can limit the social capital students can potentially gain at their time in school. Furthermore, it simultaneously creates an achievement gap between students on lower and higher tracks. Another trend was the subtle pervasiveness of the model minority stereotype and the toxic meritocratic culture attached to it. Participants seemed to share an individualistic perspective on achievement. They neglected to holistically acknowledge their own achievements in the context of their struggles, and this affected how they perceived themselves and their accomplishments. Failure to accomplish or go above expectations set by parents in the context of the traumas and sacrifices of Vietnamese refugees can translate into a heavy emotional burden. This emotional burden appeared to have an extremely negative effect on their mental health, self-esteem, and motivation.

As this is a small-scale pilot study, its limitation lies in the size and variety of the sample I collected. I chose the pool of participants based off of my own social groups and networks, indicating a skew in how the data is collected. Although I have personal relationships with all the participants and that facilitated trust and conversation, there could still be some bias in their answers. Ideally, if I were given unlimited funding and more time, I would have more participants. I would focus on people who went to college and who did not go to college, to see how certain resources were distributed between the two populations. Half of them would come from Sugar Land and the other half would come from a selected part of Harris County. Evaluating the resources distributed between schools in different Houston area districts where the Vietnamese population is more and less prevalent can illustrate a more holistic picture of the achievement disparities between differently zoned students.

Conclusion & Implications

In summary, the results of this study suggest that we need 1) disaggregated data for the AAPI population, 2) more support and discourse concerning mental health within the Vietnamese American/AAPI community, 3) more reliable community resources and outreach for first-generation students from immigrant families, and 4) education for the awareness and consciousness of students who come from different financial and multicultural backgrounds. Although the bulk of Vietnamese immigration happened more than 40 years ago, the history and culture of hardship and sacrifice translates into intergenerational issues. Many of the same obstacles that second generation and 1.5 generation Vietnamese Americans navigate in their lives will also persist in other immigrant populations. In America’s contemporary political climate, studying and advocating for the nuanced analysis of minority groups extends to all who suffer from inequities in a whitestream, racist, and classist America.
1. In order to serve the AAPI community and the diverse ethnic groups within this population, we must have the statistical data to assess the problem thoroughly and effectively. Disaggregating the data on local, state, and national levels will shed light on problems within marginalized communities and ethnic groups. Although the size of the Vietnamese American population is quite significant, the disaggregation of data would also benefit other smaller, overlooked Asian American communities.

2. Within general cultural discourse, mental health remains a taboo within the Asian American community. As a Vietnamese American, I have known several other members of my community who denied the existence and validity of depression and ADHD. Drug addictions are not viewed as a community problem, but rather the fault of an individual. The stigma associated with mental health limits healthy conversation and education on the topic. Hopefully, with more attention, conversation, and education dedicated to minority and at-risk populations, mental health can become more normalized.

3. As the results demonstrate, the social networks and connections students have access to can greatly affect their academic achievement. Navigating how and when to apply for colleges and scholarships is an extremely daunting task for any person unfamiliar with the system. Scholarships and financial aid can also determine whether one can invest their time in college. College advisory resources for first-generation students must be properly distributed between the different tracks in schools.

4. Faculty and staff must become more culturally competent and aware of student backgrounds in order to serve them ethically and equitably. While surveys and statistical data can give a cursory illustration of the student body, it is the personal relationships and mentorships cultivated between students and adult figures that can make a difference in a student’s overall performance and achievements. Jonathan, the UT student cited Ms. Apple as a significant reason for his achievements in high school and post-graduation. Connection and belonging to a community are paramount to student success and an investment in more mentorship programs and the education of staff and faculty can facilitate more positive relationships with minority students.

My findings of this pilot study point towards a future study of the psychological effects on self-esteem and self-efficacy associated with not going to college. Throughout my interviews, the shame of not meeting parental and sociocultural expectations was an extremely prevalent theme. In the future, I hope to conduct more interviews that delve into the narratives, emotions, and discourses concerning mental health and academic achievement in the Vietnamese and larger AAPI communities. This small-scale study shed light on extremely specific issues specific to first-generation Vietnamese Americans and I hope to build upon this study by addressing mental health and resource disparities in future projects.
Appendix A

1) What is your name? How old are you? What’s your current occupation?
2) Were you ever on free/ reduced lunch?
3) Did your parents go to college? How many years? What were/ are their occupations?
4) You attended _____ High School. Tell me about the student population.
   a. Can you describe your relationship with school? Could you describe your attitude towards school? How did school make you feel?
   b. What was your happiest memory from high school?
   c. Did you have memories in high school where it was difficult?
   d. Who did you go to for support if you had a problem?
   e. Were you ever in ESL?
5) How often did you think about your race at school? There’s a stereotype about how the Asian American population does supremely well in life—that we’re high performing and intelligent (e.g. we were supposed to be good at math and science). Did you ever feel like anybody (peer, teacher, counselor, family) imposed this on you during your time in high school?
6) How involved were your parents in your academic career? What kinds of things did they say about education? Were they able to be involved? Why or why not?
7) Have you always aspired to pursue this route (Earlier you said you were…..what you’re doing right now)? Did you want to go to college? What deferred you from pursuing a higher degree OR what made you decide to pursue this path? What did you dream of being when you were in high school?
8) Do you remember any specific obstacles that prevented you from pursuing your most ideal pathway?
9) Did you feel like you had access to resources that could have helped with college (e.g. scholarships, financial aid information, where to apply, how to apply, how to write application essays)?
   a. If you were making plans on going to college, who did you go to (parents, peers, counselors, teachers… anybody else)?
10) Did you take AP classes? Why/ why not? Did you feel that your classes prepared you for what you’re doing now?
   a. How did you feel about the things you were learning in school?

Each interview concluded with a reminder that this paper will not be published and that their names will be changed to protect their identities.
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Austin Texas East Riverside Gentrification: Mixed-Income Neighborhood or Racially Segregated?

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The purpose of this analysis was to build on the impressive work previously done on gentrification in the East Riverside neighborhood, by the City of Austin commissioned report, “Uprooted: Residential Displacement in Austin’s Gentrifying Neighborhoods and What Can Be Done About It,” (2018) by Dr. Heather Way, Dr. Mueller, and Dr. Wegmann. This report hopes to provide nuance to the East Riverside neighborhood, as it is portrayed previously, by utilizing a smaller unit of analysis, census block groups, as opposed to census tracts from data provided by 2010 and 2017 US Census American Neighborhood Survey (ANS). The findings are similar to larger scope reports. When looking at the smaller unit of analysis, it becomes apparent the East Riverside neighborhood is gentrifying rapidly in very concentrated areas. The other areas are increasing in vulnerable populations, which leaves them more susceptible to gentrification. These findings influence the proposal for a community land trust.

Keywords: Gentrification, Austin, Community Land Trust

Austin is the fastest growing major metro in the country (Widner, 2019), which means not only are people moving in for the tech boom, nightlife/culture, and relatively cheap housing, but the established Austin Latino communities are being pushed out to make way for the newly arrived (Way, Mueller, & Wegmann, 2018). As the historic East Side of Austin is reaching the tailend of gentrification, the process can be seen as moving outward from there, northward, and the specific topic of this report, southward. The definition of gentrification is taken from the Uprooted report, “Gentrification is a process through which higher-income households move into a neighborhood and housing costs rise, changing the character of the neighborhood.” (Way et al., 2018)

East Austin was a predominantly low-income family-oriented community of color, it is now the scene for mostly young single white professionals. While the definition of gentrification utilized in this report hinges heavily on class, race is important for various reasons explained in the methodology section of this report. However, due to historical and systemic racism a deep racial wealth gap exists (Feagin, 2013). Austin’s deep and long history of racism, segregation, and displacement (Auyero, 2015), and whose economic growth continues to increase the vast disparities of medium household incomes among race (Prosperity Now, 02/2019). In the Racial Wealth Divide in Austin report, white’s median household income is $72,341 as compared to Latino’s median household income of $44,239 (Prosperity Now, 02/2019). Thus an increase in white’s population is inherently an increase in higher class populations and as a result changes the character of the neighborhood economically, and ultimately culturally.
The East Riverside neighborhood comprises of the area within I-35, Ben White/290, Oltorf, and Lady Bird Lake. It is a predominantly working class Latino neighborhood, along with various low-income student apartments, and in close proximity to downtown. The area is the topic of various private, public, and government planning, including the East Riverside Corridor master plan, increased police presence ("Riverside Togetherness Project,” n.d.), and land speculation (Rambin, 2018). Currently, it is the home of the cloud computing giant Oracle’s South Austin campus, the beautiful Lady Bird Lake Boardwalk, and is characterized by its numerous locally owned small businesses. It’s low cost of living, convenient location, and racial diversity, brings much attention by developers such as Presidium, which are actively buying property and building housing and other establishments oriented towards higher income young white professionals (Rambin, 2018). Some of these developments include luxury style apartments, cultural businesses, parking lots, and expensive restaurants.

The focus of this study is to examine the gentrification occurring in the East Riverside Neighborhood utilizing Census data to measure increases in demographics across various indicators: higher income, higher education, and whites. How gentrification is classified as occurring is based on the method developed by Dr. Lisa Bates in the Portland study, which breaks down the gentrification process in three phases: Vulnerability, Demographic Change, and Housing Appreciation (Bates, 2013). Utilizing the smaller unit of analysis, this report will provide nuance to the gentrification occurring in the area of study. In addition, we will use a “Vulnerability Approach” (Mueller & Dooling, 2011) to include social consequences for the most vulnerable populations when recommending public policy. After examining the gentrification occurring through the East Riverside area, two potential policy proposals will be presented.

**Literature Review**

While the study of gentrification has been around since the 1980’s it has caught a resurgence. The gentrification occurring in Chicago, New York, Washington D.C., and even Austin has permeated popular media. While gentrification used to be primarily a black-white contextual social phenomenon (Lees, 2016), it has been recently challenged by the relatively recent institutional forces leading to gentrification, which when viewed through a critical race lens is seen as a result of systemic racism. So, the topic of this report is to contribute to the understanding of Latino-white gentrification, but also recognize the role the state plays in gentrification.

Next, gentrification is primarily studied through a case study of a single or group of similar neighborhoods. This report will take on the established way of researching gentrification by focusing on the specific area of the East Riverside neighborhood, and only claims to extrapolate within this area for now. The scope of this research is influenced by qualitative research done on gentrification, but the methodology takes on the qualities of more quantitative gentrification research. Utilizing ArcGIS, statistical analysis, and data from the US Census is all common practice found in quantitative gentrification analysis. The policy proposals in this report are taken from quantitative statistical analysis studies, along with the qualitative understanding of examining both the neighborhoods using these policies and the neighborhood under examination.
The usage of practices in both qualitative and quantitative studies makes this report mix-methodological in nature, albeit more on the quantitative side. The methods for determining gentrification are purely quantitative, influenced by the Uprooted report and the policies proposed are backed by quantitatively heavy research, however the positionality of the researcher, as a former resident of the area, along with the specific theoretical framework in both its analysis of gentrification and policy proposal is qualitative methodology. Analyzing the literature on gentrification, including the policy reports, the gap exists in how heavy each relies on a specific qualitative or quantitative method, this report attempts to contribute a holistic picture of the neighborhood by using best practices from both camps.

Theoretical Framework

The implications of gentrification go beyond the simple displacement of the residents which make up the character of the East Riverside neighborhood. As previously studied, gentrification disrupts the social fabric of the low-income Latino community (Betancur, 2011). The social fabric of the community in East Riverside is being torn apart due to the incoming higher income single young white residents, and resulting loss of the Latino families and working class residents. So gentrification’s impact is not simply that it displaces people, but the people who stay in the neighborhoods lives are harder due to the loss of the non-market based resources which comprise the social fabric. In addition, the psychological impact of having ones community drastically altered is also unjust to those who stayed (Tang & Desir, 2018).

How this affects the ones who stay is twofold. First, the conception of community is different for whites and Latinos (Betancur, 2011). While low income Latinos view community as a source of identity and a means for socioeconomic mobility due to the social fabric, whites view community as a commodity. For whites, land, homes, and property is valued primarily on the market value, while low income Latinos view community based on non-market value metrics. This is the reality of the racial wealth gap, which forced low income Latinos to adapt and seek fulfillment of their needs outside purely economic channels, while whites capitalized on the racial wealth gap and used their economic might to create further wealth and inequality.

Secondly, gentrification not only hampers the socioeconomic mobility of low-income Latinos by destroying the social fabric within the community and displacing many of its low income Latino inhabitants to under resourced areas further away from the urban core, but it also acts as an attack to the original community residents sense of identity and belonging (Curran, 2018). If the definition of gentrification is the resulting change of the character of the neighborhood, which is a result of wealthier individuals moving in, this is an example of the cultural change the neighborhood undergoes. The historically ethnic identity of the neighborhood and culture, is lost when higher income young single white residents began moving in.

Finally, when discussing future policy this report utilizes Dr. Mueller’s Vulnerability framework (Mueller & Dooling, 2011). This provides us with the orientation to establish policy which is equitable and just, as it takes into account the needs of the most vulnerable. We will recommend two future policies, which can be executed with or without private investors in order to improve the East Riverside neighborhood for the predominantly low-income Latino community. The combination of all four of these academic pieces provides the foundation for how gentrification and policy addressing it will be conceptualized in this report.
Method

Dr. Bates method for quantifying gentrification includes three phases: Vulnerability, Demographic Change, and Housing Market Change (Bates, 2013; Way et al., 2018). The data for these phases was obtained from the US Census American Community Survey (ACS) in 2010 and 2017. Afterwards, the maps were generated utilizing ArcGIS, and some of the percentage change was calculated utilizing the statistical analysis software Stata. In quantifying the Housing Market change, the home value data in the US Census, is self-reported which increases the risk of overestimating the values of homes.

Research has shown the neighborhoods most vulnerable and least able to withstand the rise in housing costs gentrification causes are those with a high density of people of color, low-income, heads of households without four-year degrees, and housing status renters (Bates, 2013; Way et al., 2018). This report measured the concentration of these indicators utilizing US Census data from the American Community Survey (ACS) in 2010 and 2017. The East Riverside Neighborhood map was generated utilizing US Census block groups and the indicators previously mentioned were layered into the map generated with ArcGIS. The block groups within the East Riverside neighborhood which had an exceptionally high percentage in these indicators were categorized to be highly vulnerable to gentrification. Consistent with the Dr. Bates gentrification analysis model. The limitation is the low-income population was classified as 80% the metropolitan median income ($73,800) which is quite high when compared to the East Riverside neighborhood, where many families live on $40,000 or less.

Next, demographic change was measured between 2010 to 2017 in order to quantify whether vulnerable residents were moving out and being replaced by less vulnerable residents. Less vulnerable residents are those which own their homes, have higher incomes, are white, and/or have higher levels of secondary education (Way et al., 2018). This was done utilizing US Census block group data from the American Community Survey (ACS) in 2010 and 2017. The changes were mapped out utilizing ArcGIS to generate maps displaying the demographics with statistical analysis the percentage change was calculated using the Census data and was also inputted into ArcGIS. Finally, block groups increase in house value was calculated using US Census block group data from the ACS in 2010 and 2017 and calculating the percentage change before inputting it into ArcGIS. However, the data does not indicate where vulnerable populations are going, and if they are moving back into their gentrified neighborhoods after these demographic changes.

Results

Phase I: Vulnerability

The Portland gentrification analysis model is composed of three phases. Phase I of the gentrification analysis method laid out by Dr. Bates from the Portland gentrification study consists of identifying vulnerable populations/neighborhoods. To label vulnerable block groups we look at: poverty, race/ethnicity, non college educated, child poverty, and households that rent. Neighborhoods with a large number of these populations are the ones least able to withstand the increase in cost of living gentrification causes, and are at risk of displacement (Way et al., 2018).

POVERTY

Poverty is classified as 80% below the Annual Median Income (AMI). The overwhelming majority of the East Riverside neighborhood is 50% or more in poverty. This
classifies the entire neighborhood as vulnerable. However, the US Census classifies the AMI utilizing the metropolitan area ($73,800) which is skewed much higher than the City of Austin AMI ($55,216) (“Austin, Texas Economy,” n.d.). So, while the entire East Riverside neighborhood is classified as vulnerable when utilizing the Austin Metropolitan AMI, it is important to reframe what is poverty in Austin utilizing 80% of the City of Austin AMI ($55,216) is $44,173. The second set of maps in this section breaks down the specific median income by block group and illustrate the majority of the East Riverside neighborhood is within the range of $20,000-$40,000. With some outliers in the $40,000-$80,000 range.

RACE and ETHNICITY
Minority is classified as any race or ethnicity that is not Non-Hispanic white. The overwhelming majority of the East Riverside block groups in 2010 range from 50% to 95% minority which is higher than Austin’s 2010 average minority population of 48%. This classifies the entire neighborhood as vulnerable because the majority of it is not white. However, by 2017 the growth of Non-Hispanic whites decreased the overwhelming majority of minorities, although admittedly most of the East Riverside neighborhood is still populated by minorities.

EDUCATION
Low levels of education are classified as people without a 4-year degree. The majority of the East Riverside neighborhood does not possess a four year degree with a majority of its ranges between 75% to 100% as compared to Austin’s in 2010 average of people without a four year degree being 56%. This classifies the East Riverside neighborhood as vulnerable to gentrification. Important to mention the East Riverside neighborhood is an area with various low-income student apartments, which might affect the composition of the college education attainment levels.

HOUSEHOLD COMPOSITION
Household composition is classified as percent of families with children who live in households below the poverty line. The East Riverside neighborhood block groups vary widely in percentage of how many families with children living below the poverty line comprise of. Yet, with the relatively high percentage compared to the 2010 Austin average of 9% of families with children living below the poverty line, East Riverside neighborhood, with ranges of up to 70% is labeled vulnerable.

HOUSING STATUS
Housing status is classified by percentage of households that rent. Owning homes comes with various mechanisms which enable people to remain in their communities, so block groups with higher concentration of renters are labeled as vulnerable and susceptible to gentrification. In the East Riverside neighborhood a majority of block groups have over 60% of households who rent, with many as high 95%. This is much higher than the Austin average of households that rent (47%) and is labeled as vulnerable.

Phase II: Demographic Change
Phase II of the gentrification analysis method laid out by Dr. Bates from the Portland gentrification study consists of quantifying demographic change indicative of gentrification. To chart the degree of gentrification we look at: Non-Hispanic white population, median household
income, college education, owned housing units. Neighborhoods with increases in these indicators are labeled to be gentrifying (Way et al., 2018).

HOMEOWNER RESIDENTS

Homeowner Residents is classified by the change in homes owned from 2010 to 2017. Figure 1 shows the percentage change of homeowners and the total number of homeowners in 2010. The reason for providing both the actual number of homeowners and percentage change is to provide context for specific block group changes. The majority of the East Riverside neighborhood saw a decrease in homeowners, however very few homeowners existed in the first place.

Figure 1. Total number of Homes Owned and Change of Homes Owned from 2010-2017
INCREASE NON-HISPANIC WHITE POPULATION

Increase in non-Hispanic white population is classified by the increase in the percentage of non-Hispanic whites per block group. Figure 2 shows the percentage change of non-Hispanic whites from 2010 to 2017, and the total number of non-Hispanic whites in each block group in 2010. The reason for providing both the actual number of whites and the percentage increase is because of the racial/ethnic composition of many East Riverside neighborhood block groups. Some block groups had so few whites in 2010 that even a modest increase in absolute number of whites can make a large percentage difference.

Figure 2. Total non-Hispanic whites and change of non-Hispanic white from 2010-2017
HIGHER INCOME

Higher Income is classified by the percentage increase in median income change per block group. Figure 3 illustrates the increase in median income from 2010 to 2017. The block groups are divided by how many saw an increase in median income and decrease in median income. However, the block groups which had an increase, while most were in the 0% to 50% range 2 saw an increase of more than 75% and two others saw an increase of over 50%. This demonstrates the nuance occurring in the East Riverside neighborhood, while in the larger scale census tract level it can be argued minimal increase in median income is occurring, at the block group level, we see gentrification is occurring in very concentrated pockets of East Riverside.

Figure 3. Median Income Percentage Change from 2010-2017
HIGHLY EDUCATED

Increase in highly educated is classified by the decrease in the percentage of people without a 4-year college degree. Figure 5 illustrates the percentage change of people without a 4-year from 2010 to 2017, and the total number of people without a 4-year degree in each block group in 2010. The reason for providing the actual number and percentage change is to provide context behind some block groups percentage changes. The block groups which possess both a high number of people without 4-year degrees and high decrease of people without 4-year degrees are the most gentrified.

Figure 5. Total Adults without a 4-year degree and Percentage change of Adults without a 4-year degree from 2010-2017

Phase III: Housing Appreciation

Phase III of the gentrification analysis method laid out by Dr. Bates from the Portland gentrification study consists of identifying increase in cost of housing. To chart the degree of housing cost, we look at: Housing appreciation. Neighborhoods with increases in this indicator are undergoing gentrification (Way et al., 2018).

HOUSING APPRECIATION

Housing appreciation is classified by an increase in median home value change per block group. Figure 6 illustrates the percentage of change in median home value from 2010-2017, and
the median home value in each block group in 2010. The reason for providing both the actual median home value and the percentage change of median home value is to contextualize what is occurring in each block group. The block groups who experienced a decrease in median home value, were also consistently the ones with the lowest median home value in 2010. While the opposite was true for a majority of the block groups with the highest median home value in 2010 saw an increase in median home value from 2010 to 2017.

**Figure 6. 2010 Median Home Value and Home Value percentage change from 2010-2017**

### Conclusion

The East Riverside neighborhood can be characterized as gentrifying due to its increase in housing costs. However, when analysed from the larger census tract level, one could argue to the contrary. Yet, when analyzed from the smaller census block group level, we see the immense segregation occurring among the block groups. The most desirable/expensive portions of the East Riverside neighborhood are gentrifying rapidly, while the least expensive areas, characterized by larger numbers of vulnerable populations, are being neglected at the state, city, and local level. This is increasing the density of vulnerable populations which can result in expedited gentrification.

To account for the large percentage of vulnerable populations the policies this report recommends are establishing an East Riverside Community Land Trust, which have been
statistically proven to stop if not reverse displacement due to gentrification (Choi et al., 2018). The second policy to be recommended is building various Low-Income Housing Tax Credit program eligible developments in the specific block groups most gentrifying (Woo et al., 2016). This will lead to the creation of a sustainable mixed-income community without the consequence of displacing the most vulnerable.
References


Epistemic Agency in Argumentative Driven STEM Design

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Science education is moving away from the traditional scientific method, where students are guided and instructed on how to produce science, to a method led by student curiosity and instinct. There is a move towards science classrooms that reflect the epistemic agency of their students. In order for science to have a greater impact on students, and for it to be more accessible, the student’s interest and intellectual instinct must be placed at the forefront. This study hopes to gain an insight on the development of student epistemic agency – students being positioned as constructors of science knowledge – in two middle school classrooms through the educator’s perception of this concept, as well as ways that it is supported, or hindered, in the classroom. The context of these classrooms is focused on students piloting STEM Design Challenges that allows them construct knowledge through argumentation and teachers’ pedagogical responses to the new roles the design challenges require. Through teacher interviews and classroom videos, the study will explore the factors that influenced the growth of students’ epistemic agency during these design challenges.

INTRODUCTION

The move towards students constructing science by pursuing their theories and instincts on experiments must begin with understanding how teachers’ views of students’ epistemic agency are conveyed through the classroom culture they create. It is important to see how teachers who are welcoming towards this movement create a classroom that supports epistemic agency and when, if at all, this classroom culture is placed on the back burner. This research strives to gain insight on how teachers’ definitions, or understandings, of epistemic agency affect the creation and support of argumentative STEM design challenges that focus on students’ epistemic agency. Epistemic agency, which we conceptualize as:

How students are positioned as agents responsible for constructing knowledge in the community (Stroupe, 2014)
The ways students act with epistemic agency as they construct knowledge through science practices (Miller et al., 2018)

Thus, our conceptualization of epistemic agency considers two aspects. The first is categorized by the opportunities provided in classrooms, by teachers, that enable and support epistemic agency. This is the focus of this research study, as we will focus on teachers’ understanding of epistemic agency and ways that their instructional practices support, or not, their students’ epistemic agency. The second conceptualization is focused on the self-actualization of the student. On the student side, it is important for students to recognize their agency and act on it as they work with peers to develop explanations of scientific phenomena.

This research hopes to develop an understanding of two middle school teacher’s understanding of epistemic agency, explore how the teachers support and, or, constrain their students’ epistemic agency, and examine how these teachers’ perspectives change as a result of
engaging in argument driven STEM design challenges. We do so by focusing on the following questions:

1. How do teachers enacting the ADE units understand epistemic agency as it relates to their students and their engagement in ADE?
2. How do teachers enacting ADE units support (or not) their students’ epistemic agency?
3. How do teachers’ views change from experiencing the ADE units?

LITERATURE REVIEW

Knowledge Considered as Science

Epistemic agency in this research is focused on the students and their ability to construct science with the support of their teachers. Being that this is occurring in a science classroom, it is important for teachers to recognize their position on what they consider science to be. There exist TEKS that must be met within the science classroom but focusing on these and viewing them as the sole knowledge can lead to negative effects on students and their ability to enact their epistemic agency.

The binary of ‘right or wrong’ science can affect student participation in the classroom (Stroup, 2016). When teachers set out to look for specific understandings of a content, the value they set forth on their students’ responses will have a hierarchy. This can then further influence the students’ own value of responses. Therefore, students who do not feel their ideas align with the ‘correct’ science will limit themselves in their participation and their ability to construct knowledge.

Student participation in sharing ideas is not the only manifestation of epistemic agency that can be hindered. Expectations of a certain way of doing science or what constitutes as science can lead to students and teachers only legitimizing data and ‘known’ science (Jung & McFadden, 2018). Therefore, the students are limited in the ways they construct knowledge and can become data or instruction focused which is the shift that is trying to be moved away from.

The hierarchy of what makes up science knowledge can, furthermore, affect how students’ grasp of the content is perceived. Students whose explanations might be perceived as misconceptions could be interpreted as students who are not grasping the concepts, although, the sharing of these students’ sensemaking can be seen as a manifestation of their epistemic agency (Haverly et al., 2018). Thus, there exist conflicting goals on what is considered as knowledge and what students share.

Group Constructed Knowledge

The sharing and exchange of ideas is focal in students exhibiting their epistemic agency. The classroom is meant to be a space for shared knowledge where everyone contributes to the construction of science. This construction of knowledge through epistemic agency consists of students identifying knowledge gaps in their understandings, sharing the information they gather and ideas they come up with, and creating a communal knowledge that the class legitimizes (Lai et al., 2018).

It is due to the creation of communal knowledge that there must exist an alignment of scientific knowledge and the classroom community (Berland et al., 2016). The constructed
knowledge in the classroom, by students, must be validated and align with the scientific knowledge that already exists. Thus, through shared epistemic agency amongst the class (Damșa et al., 2010) the two knowledges can coexist and unite. However, there exists a contradiction of what epistemic agency is meant to be, specifically in NGSS, and how to make that a reality (Miller et al., 2018).

*Meaningful Work*

In addition to the need for alignment between scientific and classroom constructed knowledge, it is important for students to find meaning in the activities and work they are engaging in. Accounts of student agency need to be constructed in ways that are mindful to them (Arnold & Clarke, 2014). Students must be cognitively aware to the underlying meaning in their work and must be aware of their agency. Thus, epistemic agency is manifested when students are aware that they are the ones choosing to engage in constructing science and that the knowledge and skills they are developing go beyond classroom work.

**METHODS**

The study centers around multiple-case study methodology. This research method allowed us to explore the relationship between the teachers’ understanding of student epistemic agency and how it manifests in their classroom. Thus, we can explore how teacher understanding play with their support of students constructing science.

*Participants*

Given the study’s focus, the participants include two middle school science teachers from a public school in central Texas. Specifically, one of these 8th grade teachers is a white male and the other is a black female, both with over ten years of teaching experience, and thus they would not be considered new teachers.

*Data Collection*

In order to see how teachers’ understanding of epistemic agency is exhibited in their classroom, we will observe the teachers’ instruction in the videos of two argumentation driven STEM designs. Through these videos, we will be able to see how teacher actions align with their understandings. We will also transcribe the teachers’ three interviews: a pre-study interview, a post ADE design one, and a post ADE design four. Using current literature, we will create two different coding schemes – one that will be used to examine teachers’ understanding of epistemic agency, and the other to explore their classroom instruction. Along with the active awareness of agency that students have, meaningful work motivates students in doing the work they are doing (Berland et al., 2016).

**FINDINGS**

During our time, we focused on analyzing the teacher interviews. The interviews center on investigating the teachers’ sensemaking of student epistemic agency. After members of the
team read and coded the transcribed interviews, there were certain notable shared factors that impacted teacher sensemaking, as well as contrasting factors. The research is ongoing and is currently in the process of finalizing the factors of teachers’ sensemaking of student epistemic agency.

DISCUSSION

The current science education is one void of student freedom. It focuses on teaching students to memorize a to-do list of instructions for learning science, as opposed to allowing them to pursue their intuitions and make discoveries on their own. The ability for students to take their learning into their hands is encompassed in the creation and support of student agency. This research will allow us to see how teachers’ understanding and support of this agency plays a role in their class, specifically through the exploration of argumentative driven STEM designs.
REFERENCES


Improving Ribosome Profiling Pipeline through Analysis of Unaligned Sequences

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Translation is the process by which mRNA nucleotide sequences are converted into an amino acid chain. Translation is a fundamental biological process that facilitates the diversity of life. Despite its immense importance, our knowledge of translation regulation remains limited. To study translation on a global scale, the current state-of-the-art method is ribosome profiling. This method relies on next generation sequencing of RNase degradation resistant mRNA fragments that are protected by ribosomes. Analysis of ribosome profiling data at nucleotide length resolution can provide valuable insight into the kinetics of protein synthesis. However, processing ribosome profiling data requires the association of thousands of values to each transcript. This makes ribosome profiling data difficult to analyze and display through traditional methods. Moreover, certain RNAs, such as tRNA fragments and rRNAs, are also captured in addition to the protected mRNA. To solve these problems, we are developing a novel pipeline, called RiboFlow that can effectively analyze, store, and display ribosome profiling results directly from the sequencing data. Our pipeline filters the sequencing data before aligning them to the transcriptome and genome. Some sequences fail to be captured and result in unaligned sequences. This may occur due to the filter missing certain RNA types of practical consideration, like pre-ribosomal RNAs. We worked on identifying the unaligned sequences through sequence assembly and basic local alignment. This method provides direct feedback to improve the efficacy of our filter. To leverage the high sequence similarity among unaligned reads, we used the velvet assembler to construct longer sequences that can be more efficiently identified using the basic local alignment search tool (BLAST). We were able to determine many different origins of unaligned sequences, including BAC clones, rRNAs, and tRNAs. These findings will be implemented in improving RiboFlow filtering and future analysis of ribosome profiling data.
**Introduction:**

Translation is one of the most important and energy costly processes a cell undertakes. It involves the conversion of the mRNA nucleotide information by ribosomes, complex macromolecules composed of rRNAs and proteins.

To gain a better understanding of translation mechanisms, we must understand how ribosomes interact with mRNA transcripts. During translation, ribosomes attach onto the mRNA and protect a short segment (~21-30 nucleotides) of mRNA, which is referred to as a “ribosome footprint” [1].

Ribosome profiling is an approach to determine the transcriptome-wide locations and mRNA engagements of ribosomes by degradation of unprotected mRNA sequences and isolation of the remaining ribosome footprints. The ribosome footprints are then converted into cDNA libraries, which can be sequenced through next generation sequencing. Identification of ribosome footprints provides information of ribosome locations on a global scale [Fig 1]. This allows for the study of ribosomal movement and how it is influenced by mRNA sequences [2].

Ribosomes undergo conformation changes that lead to different read lengths of ribosome footprints. Consequently, ribosome profiling data pose a significant challenge for visualization and analysis given that thousands of reads per transcript are generated [3]. Currently, there is no specialized computational pipeline that can provide analysis of ribosome profiling data as a function of ribosome protected fragment lengths. We created a pipeline, named RiboFlow, to address this need.

RiboFlow processes ribosome profiling data in a series of steps, including clipping, filtering, and alignment [Fig 2]. Raw data from ribosome profiling experiments contain sequencing adapters that are not relevant to the experiment. It also contains components outside of the transcriptome, like rRNAs. Although these components should be digested with RNase, they are often present in sequencing data in practice. RiboFlow pipeline first clips off the sequencing adapters then filters out results irrelevant to the transcriptome. After these initial steps, RiboFlow identifies the resulting transcripts by aligning them to the transcriptome and genome databases. However, the current analysis resulted in unaligned sequences that revealed missing information in the databases we used. To improve the efficacy of our filter database, we identified the origin of these unaligned sequences and created supplemental databases from select sequences.

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**Figure 1. Ribosome profiling protocol**
Graphical illustration of a typical ribosome profiling workflow. Source: Ingolia...Weissman et al., 2009
Figure 2. RiboFlow Pipeline workflow
Flowchart depicting the steps RiboFlow takes to extrapolate information from ribosome profiling raw data. Steps including clipping, filtering, and alignment. Colored boxes are for data. Grey boxes are the analysis steps. Orange box is for the unaligned sequences used to improve the efficacy of filter reference database.
Results:

Sequences we had high confidence in were incorporated into the filter reference of the pipeline. Other sequences that might lead to false filtering of transcripts were added to an additional diagnostic step the very end of the pipeline. In addition to retrieving tRNAs, snRNAs, and rRNAs sequences from the national center for biotechnology information (NCBI) database, we also included piRNAs from the piRBase database [regulatoryrna.org].

A comparative analysis of the new and old filter was performed [Fig 3]. Overall, we were able to increase the amount of filtered sequences by sixteen percent while maintaining low loss on the number of aligned transcript reads.

Discussion:

Our goal is to capture additional transcripts that previously failed to align to the genome and transcriptome while refraining from over-filtering informative sequences. After identifying the unaligned sequences, we made judgements on whether these sequences should be filtered. Since there are millions of total sequences, the filtering effect may never be perfect. However, we were able to ensure that the number of additional filtered sequences did not result in significant decrease of transcriptome alignment results. This indicates that our new filter database was able to capture previously unaligned sequences.

Methods:

We used the unaligned sequences as a feedback mechanism for improving our filter. Many unaligned sequences only have minor shifts and mismatches, so we assembled them using the velvet assembler [4]. Representatives of the assembled sequences were identified using the
basic local alignment search tool (BLAST) [5], because it contains a greater variety of sequences from other cell lines and experiments compared to our transcriptome and genome database. Once identified, the complete sequence was added to our filter reference [Fig 4]. In addition to our in house generated data, we also applied this approach to a published ribosome profiling data from Dr. Rachel Green’s lab.

Figure 4. Unaligned sequences analysis protocol
Unaligned sequences are assembled using velvet then locally aligned through BLAST before being added to the filter reference.
Reference: