The Extent to which the allocation of toilet types in BNDS Aspiration Building accord with Students' preferences: Take Gender as a Confounding Variable

Tony, Louie, Alan, John

Abstract

In China, a traditional oriental country, the Aspirational Building, the classroom building of the BNDS International Department, features sit toilets instead of squat toilets in the bathrooms to accommodate the bathroom preferences of foreign teachers. This research paper evaluates the effectiveness of current allocation of toilet types in the International Department of Beijing National Day School by conducting hypothesis tests. Since gender can be a potential confounding variable, we tested the independence between student preferences and genders. Based on the result, Gender in our research is indeed a confounding variable. Based on this, separate hypothesis tests were conducted to assess the goodness of fits between the existing allocation and the preferences of students of respective genders. The end of the paper provides gender-specific recommendations for toilet improvements in the BNDS International Department. The research can provide a model for high school students to learn how to test the effectiveness of current facilities and provide suggestions for improving the facilities of their schools of different cultures.

Contents

1 Introduction **1**

2 General Assumption **2**

3 Data Collection and Data Processing **2**
3.1 Obtain the Current Toilet Type Allocation 2
3.2 Obtain the Students' Toilet Type Preference 2
3.3 Summarize and Transform The Data From Questionnaire 3

4 Methods and Results **4**
4.1 Notations 4
4.2 Determine the Independence Between Gender and Preference 4
4.2.1 Data 4
4.2.2 Hypothesis 4
4.2.3 Check Conditions 4
4.2.4 Result 5
4.2.5 Conclusion 5
4.3 Hypothesis Test on the Preference of Male 5
4.3.1 Data 5
4.3.2 Hypothesis 6
4.3.3 Check Condition 6
4.3.4 Result 6
4.3.5 Conclusion 6
4.4 Test on the Preference of Female 6
4.4.1 Data 6
4.4.2 Hypothesis 7
4.4.3 Check Conditions 7
4.4.4 Result 7

5 Discussion **8**
5.1 Advantage 8
5.2 Disadvantage 8

6 Conclusion **8**

1 Introduction

The international department of BNDS has the largest international faculty proportion in all the international high-school programs in Beijing. According to Jun Tian, the school president, the school administration has attached to an open philosophy of aiming to build a diversified and international high school and invested considerable funds in constructing the classroom building (Aspirational Building), in particular for the International Department. During construction, the relevant department, considering the bathroom usage preference of foreign teachers, equipped the Aspirational Building with many sit toilets in bathrooms. As a result, there is only one sit toilet per bathroom in our department, whereas in the national department building, squat toilets are instead the outliers, according to our observation.

Such an uneven allocation of toilet types in the Aspirational Building indeed has some reason. Squat toilets are provided to accommodate Western teachers' bathroom preferences. It is acknowledged that there are significant biological differences between Western and Eastern individuals when it comes to using toilets. According to a piece of research, most Western people, when performing a task that requires lowering their body to the ground, usually do it with "genuflection (one knee on the ground), kneeling (both knees)[3]". They cannot perform "Asian Squat" – a position that allows for reducing pressure on joints and bones. In fact, they cannot squat unless with their heels up, sacrificing balance and stability[3]. When they use squat toilets, their knees, feet, and lumbar become awkward[4]. Therefore, their unique biological attribute disables Western people from using squat toilets.

Nonetheless, people should not omit the fact that in BNDS, teachers have their own bathrooms in teachers' resting areas on each floor prompts us to research this issue, which means "the bathrooms" are actually for students, a vast majority of which are Chinese natives.

The current allocation of toilet types, accordingly, has resulted in some inconvenience for some people, which deserves some consideration. For instance, as a small survey, two of our four team members report a surprisingly similar preference for using squat toilets to sit toilets and experience of usually being unable to find a spot when needed. We strongly believe that this small survey within our research group is not an accidental case. Rather, our shared experience has prompted us to be strongly skeptical of the validity of the current toilet type allocation. Our research group then aims to conduct statistical hypothesis tests to test whether the current allocation of toilet types accords with the preference of students and provides suggestions on how to improve the toilet type allocation.

On a side note, Gender can be a confounding variable. Research has supported that women, due to sanitation concerns, are more reluctant to use public [sit] toilets compared to men[2]. In order to gain numerical support on the knowledge whether in this research context Gender is actually a confounding variable, we managed to use a hypothesis test to test the independence between the population student preferences and genders. If it is true – as is with the result – we will conduct separate tests to test the identity between the preference of the toilet types for each gendered student population and the current toilet type allocation in the respective bathrooms. This allows us to provide specified suggestions that are customized based on gender for the International Department toilet improvement.

2 General Assumption

- **Assumption 1**: The toilets we are discussing are all in the Student bathroom.
  ↪ **justification**: As discussed in the last section, teachers have their separate restrooms and toilets, so we can assume the bathrooms in the doorway are for and will primarily be used by students. Therefore, only the preferences of students are collected.
- **Assumption 2**: The toilets we are discussing are in the Aspirational Building floor one to floor eight.
  ↪ **justification**: only floors between floor one to floor eight – excluding the B1 Floor – are used by students of international departments, the population to be generalized.

3 Data Collection and Data Processing

3.1 Obtain the Current Toilet Type Allocation

Our team observed the men's toilets from the first floor to the eighth floor of the International Department Building and calculated that the ratio of sit toilets to squat toilets in male bathrooms was 59:13. However, as this research group consists of male students only, we have to ask for help from some female students to complete the data collection process. We finally obtained the ratio for female bathrooms, which was 129:13.

Table 1: The current toilet type allocation

	Sit Toilet	**Squat Toilet**	**Total**
Male	59	13	72
Female	129	13	142
Total	188	26	214

The table 1 shown represents the data of the observation

3.2 Obtain the Students' Toilet Type Preference

For the questionnaire, we used a simple random sampling method to give all the students a numbers from 1 to 750, given that there are 750 students in the International Department, as G11 Director Arial Li estimates. We used a random number generator to generate 50 unique numbers. Based on these 50 numbers, we found the corresponding 50 students in reality and had all of them answer the questionnaire. The questionnaire is shown in 1

关于坐便器或蹲坑的倾向调查（The Research on the preference of squat toilet or sit toilet)

第1题：您的性别? (Gender) [单选题]

选项	小计	比例
男（Male)	31	62%
女（Female)	19	38%
本题有效填写人次	50	

第2题：您对于坐便器和蹲坑的偏好? （Squat or Sit Toilets) [单选题]

选项	小计	比例
坐便器（Sit Toilets)	29	58%
蹲坑（Squat Toilets)	10	20%
没有偏好 两者都可以（Either)	11	22%
本题有效填写人次	50	

Figure 1: The questionnair

3.3 Summarize and Transform The Data From Questionnaire

There were 31 male and 19 female students. From the information obtained by the questionnaire, we can know that among the 19 female students, 6 preferred squat toilets, 8 preferred sit toilets, and 5 preferred both. Among the 31 male students, 4 preferred squat toilets, 21 preferred sit toilets, and 6 preferred both. The people with neutral opinions on this problem are not outliers and hence should not be ignored. To include the neutral opinion into consideration, we adopt a special coding system, in which the vote is the unit. Under this system, each of those who chose “squat toilets” in the questionnaire is assigned two votes for squat toilet, each of those who chose “sit toilet” is assigned two votes for sit toilet, and each of those who chose ”Either” is assigned with two votes with one for each toilet type. The results are shown in table 2.

Table 2: The data from questionnaire

	Sit Toilet	**Squat Toilet**	**Total**
Male	48	14	62
Female	21	17	38
Total	69	31	100

4 Methods and Results

4.1 Notations

Table 3: Notation and Description

Notation	Description	Notation	Description
X^2	The statistic chi-square value	df	Degree of freedom
E_{sit}	The expected value of sit toilet	E_{squat}	the expected value of squat toilet
n_{sample}	The sample size	n_{toilet}	The total number of toilet
P_{sit}	The proportion of sit toilet	P_{squat}	The proportion of squat toilet

4.2 Determine the Independence Between Gender and Preference

We conduct a chi-square test for independence between gender and preference on toilet type.

4.2.1 Data

Based on the observed counts provided in table 2, we calculated the expected counts as shown in table 4.

Table 4: The expected counts of the data from table 2

	Sit toilet	**Squat toilet**
Male	42.78	19.22
Female	26.22	11.78

4.2.2 Hypothesis

H0: The students' preferences are independent of students' genders.
Ha: The students' preferences are not independent of students' genders.

4.2.3 Check Conditions

- From the table 4, all expected counts are greater than 5.
- All samples are randomly selected.

4.2.4 Result

Table 5: The summarize of the result of the chi-square test for independence

Variables	**Quatity**
X^2	5.407
p-value	0.02
df	1

The result of the Chi-square test for the independence between the students' preferences on types of toilet and gender is shown in 5

4.2.5 Conclusion

Since p-value $= 0.02 < \alpha = 0.05$, we have sufficient statistical evidence that the students' preferences are dependent on students' genders.

4.3 Hypothesis Test on the Preference of Male

We now know that gender is a confounding variable. In order to avoid its impact, we conduct Chi-square test for Goodness of Fit for the toilet type preference of male student population, so as to see if the current toilet type allocation accords with each gendered students' demand.

4.3.1 Data

Although the population changes, we use the same dataset collected previously because the data collection process should be ultimately the same, and the expected preference of males and females are the same too.

Table 6: The data used in the hypothesis test on the preference of male

	Sit Toilet	**Squat Toilet**
Expected	49.406	12.594
Observed	48	14

The expected counts are calculated with equation 1, where $n_{\text{m}\cap\text{sit}}$ is the number of sit toilets in the male bathroom, and $n_{\text{m}\cap\text{sit}}$ is the number of squat toilets in the male bathroom.

$$\begin{aligned} E_{\text{sit}} &= n_{\text{sample}} \times \frac{n_{\text{m}\cap\text{sit}}}{n_{\text{toilet}}} = (48+14) \times \frac{51}{51+13} \\ E_{\text{squat}} &= n_{\text{sample}} \times \frac{n_{\text{m}\cap\text{squat}}}{n_{\text{toilet}}} = (48+14) \times \frac{13}{51+13} \end{aligned} \tag{1}$$

4.3.2 Hypothesis

H0: $P_{\text{sit}} = \frac{51}{51+13}$, $\text{P}_{\text{squat}} = \frac{13}{51+13}$
Ha: At least one of the fractions is incorrect

4.3.3 Check Condition

- All expected counts in 6, as shown in the table above, are greater than 5.
- All samples are randomly selected.

4.3.4 Result

Table 7: The summarize of the result of the chi-square test for Goodness of Fit

Variables	**Quatity**
X^2	0.197
p-value	0.657
df	1

The result of the hypothesis test on the preference of male is shown in 6.

4.3.5 Conclusion

Since p-value$= 0.657 > 0.05 = \alpha$, we fail to reject the null hypothesis and conclude that there is no convincing evidence of a significant difference between the current allocation and the toilet type preference of the male student population.

4.4 Test on the Preference of Female

We conduct a chi-square test for goodness of fit for the preference of the toilet types for the female student population.

4.4.1 Data

Table 8: The data used in the hypothesis test on the preference of male

	Sit Toilet	**Squat Toilet**
Expected	34.521	3.49
Observed	21	17

In table 8, the expected value are calculated with equation 2.

$$E_{\text{sit}} = (43 + 33) \times \frac{129}{129 + 13}$$
$$E_{\text{squat}} = (43 + 33) \times \frac{13}{129 + 13} \tag{2}$$

A problem comes, as the expected count of expected data of squat toilet is less than 5, making the distribution of X^2 not fit well into the chi-square distribution. Thus, in order to enlarge our sample size to increase the expected counts, we use a bootstrapping sampling method[1] to achieve this goal.

We first randomly select votes from the original sample data with replacements, given that the "with replacement" allows each observation to be chosen independently and possibly selected multiple times. This step generates a bootstrap sample that retains the same size as the original dataset but may contain repeated observations while missing others.

We then repeat the process twice and get a bootstrapping dataset size of 38, twice that of the original dataset.

Table 9: The data used in the hypothesis test on the preference of male

	Sit Toilet	**Squat Toilet**
Expected	69.042	6.9
Observed	43	33

The table 9 represents the data after bootstrapping sampling.

4.4.2 Hypothesis

H0: $P_{\text{sit}} = \frac{129}{129+13}$, $P_{\text{squat}} = \frac{13}{129+13}$.
Ha: At least one of the fractions is incorrect.

4.4.3 Check Conditions

- From the 2, all expected counts are greater than 5.
- All samples are randomly selected.

4.4.4 Result

Table 10: The summarize of the result of the chi-square test for Goodness of Fit

Variables	**Quatity**
X^2	104.059
p-value	1.96×10^{-24}
df	1

Since p-value= $1.96 \times 10^{-24} < 0.05 = \alpha$, we reject the null hypothesis and conclude that there is convincing evidence that there is a significant difference between observed value and expected value.

5 Discussion

5.1 Advantage

Our study is an observational study. The results can be summarized to all the students in the International Department Building. In addition, it can help our school to improve the distribution of squat toilets and sit toilets in male and female bathrooms in the International Department building. We used bootstrapping method on processing data. This method especially useful when collecting data takes a lot of time and effort.

5.2 Disadvantage

The use of bootstrapping method may change the distribution of the original data, which may lead to errors in the results. The lack of sample size will lead to inaccurate results in our analysis. Non-Response Bias—Some female students didn't finish the questionnaire after distribution of the questionnaire.

6 Conclusion

Based on the statistical inference tests conducted with a significance level of 0.95, Gender is a confounding variable. The results indicate that there is a significant need for more squat toilets in the female bathrooms of BNDS International Department, while no significant change in male bathrooms is needed. It is recommended that the school administration takes this suggestion into consideration and takes steps to equip additional squat toilets specifically in the female bathrooms.

References

[1] Bradley Efron. Computers and the theory of statistics: thinking the unthinkable. *SIAM review*, 21(4):460–480, 1979.

[2] Kimmo Eriksson, Thomas E Dickins, and Pontus Strimling. Global sex differences in hygiene norms and their relation to sex equality. *PLOS Global Public Health*, 2(6):e0000591, 2022.

[3] Rakesh Goyal, Shakti A Goel, and Nishant Bhatia. Determination of outcomes of complex upper end tibial fractures in squatting and cross leg sitting south asian population. *Injury*, 52(6):1569–1576, 2021.

[4] Fanjia WANG, Chenlei ZHOU, Lina LUO, Shangjun HUANG, and Wenxin NIU. Comparison of the lower limb kinematics and muscle activation between asian squat and western squat. *Journal of Medical Biomechanics*, pages E705–E711, 2021.