Problem Analysis and Optimization of Public Toilet Design in a University Teaching Building Based on Human Factors Engineering Theory

Zhanghuang Xie

School of Economics and Management, Fuzhou University, Fuzhou 350108, Fujian, China

Abstract: Based on the collection of 539 questionnaires from different populations that people spend an average of 36 minutes a day in the toilet, which is 14 minutes on average for the toilet, equivalent to more than two years time in the toilet, so the personalized design of toilet has become a big demand of human beings. This study will take the toilets in the West No.1, East No.1 and Wen No.1 teaching buildings of a university as the research objects with personalized and rationalized design of toilets as the main research content. Through the field investigation and issue of questionnaires on the toilets in the three teaching buildings, the characteristics and deficiencies of the toilets in the teaching buildings of universities are explored. On this basis, based on the knowledge and practice of human factors engineering, environmental behavior, psychology and other related disciplines, this paper puts forward some methods and suggestions to solve the toilet problems in teaching buildings of this school.

Keywords: university, teaching building, toilet design

1. Research background

Modern life endows public toilets with multiple identities. It is no longer limited to solving physiological needs, but also must meet spiritual needs such as rich functions, comfortable environment and humanized design, so as to give certain psychological responses to users [1]. Data show that in the future, China will return to the peak of the school-age population in higher education, which means that the number of universities will be greatly increased, and in the teaching building design. It means that the number of university students will be greatly increased. In the design of teaching building, in order to ensure the area and design quality of the main use space such as classroom and laboratory, the area of toilet, which is also an important part of the building, is gradually compressed, and its design has been ignored [2].

2. Research objectives

Under the background of many problems in the design of toilets in colleges and universities and the development of the proposal competition of the university, this study carried out field research on the teaching buildings of The West No.1, East No.1 and Wen No.1 of the university. We collected toilet relevant data and investigated answer sheet data, and according to relevant human factor engineering Psychology and environmental behavior and targeted by the questionnaire of students behavior process and toilet toilet psychological study, we summed up the toilet design of unreasonable problems or needs to be improved, and one by one analysis, put forward the corresponding solutions and related opinions, public toilet for colleges and universities Urban public toilet design and designers to provide some ideas and suggestions

3. Research methods

There is comparative analysis, logic analysis, hypothesis analysis, analogy analysis, and legend analysis.

4. Questionnaire

Table 1. Details of questionnaire distribution

Number of questionnaires issued	Number of questionnaires returned	Number of valid questionnaires	Recovery rate	Effective rate
600	545	539	90.8%	98.9%

5. Problem analysis and optimization of toilet design

5.1 Toilet layout

It can be found from the questionnaire that women pay more attention to toilets than men. Meanwhile, the layout of toilets in the three teaching buildings is arranged at the end of the building, leaving a terminal space for toilets, just because it is easy to be neglected. However, as the three teaching buildings are spread out in a large area, only setting up the toilet at the end can not meet the needs of users. The situation is most serious in Dongi. At the same time, due to the end of the space enclosure is strong, good privacy, strong sense of space, making people easy to magnify the external environment for sensory stimulation, so the unscientific design will bring a greater impact on people. During the break, students who are far away from the toilet need to go through a longer time to reach the toilet; Students who study at night need to go through a long corridor with low light to reach the toilet, which even causes many safety problems. Accordingly, can consider to add toilet in middle.
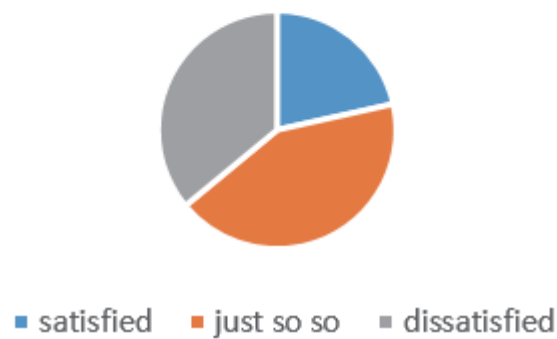
Figure 1. Students' satisfaction with toilets

Figure 2. Gender of the person filling in the questionnaire

5.2 Internal design of toilet

5.2.1 Squatting ratio of male and female toilets

According to the survey, there are lines of women to go to toilets, while men's toilets are often empty, so it can be seen that the original teaching building sanitation facilities have been unable to meet the current proportion of male and female

college students.

In essence, the reasons can be divided into physiological reasons and physical reasons. From the physiological point of view: the male urethra is longer, can accumulate urine; The length of female urethra is only a quarter of that of men, that is, male urine is in the elimination of urethra accumulation of urine, and women are in the elimination of urethra and bladder urine. From the physical point of view: men stand urination, relative to women faster and more smooth. According to the survey on public toilet facilities in London in 1992, women spend more time using the toilet than men, and the average time of women is twice that of men. Relevant data also show that the average time of men and women urinating in the toilet is (39±6) seconds for men and (90±7) seconds for women [3].

In order to get more accurate data, I selected the toilet on the first floor of Wen Yi As the research object during the big class period from 10:00 to 10:20 in the morning, and obtained the following results.

Table 2. Number of toilet users and time statistics

Items	Male toilet	Female toilets
Date	May 13, 2021 10:00-10:20	
Number to go toilet	13	30
Average time in toilet	43s	96s
Conclusion	1. The frequency of women to use toilet is much higher than that of men. 2. Women took more time in toilet than men. 3. The results were consistent with the preliminary questionnaire survey.	

Based on this, I think: The number of toilet sanitation facilities is calculated through the use of scale, according to the method of statistical probability, determine the number of facilities that users think is satisfactory and convenient. Therefore, the determination of the number of toilet facilities and the number of users and service radius are closely related. However, in university teaching buildings, the number of users is relatively flexible, so we can consider the maximum number of users within the service radius and determine the proportion between the number of users and the health facilities of men's and women's toilets based on the characteristics and construction of the school. At present, the squatting ratio of the school is about 2:3.

According to the Urban Public Toilet Design Standard issued by the Ministry of Housing and Urban-Rural Development of China, the ratio of male and female squatters in public toilets in scenic spots is 1:2, but during the investigation, it was found that the ratio of male and female toilets in most buildings is 2:3. However, in public places such as university campuses, this ratio of women's toilets still fails to meet the needs of users. For this reason, I investigated the squatting ratio of male and female in public toilets of teaching buildings in the questionnaire. The survey showed that the majority of squatting ratio of male and female toilets was 2:5, followed by 1:2 or 1:3. However, in teaching buildings, it is difficult to achieve the ratio of 2:5. The size required by the number of sanitary facilities will greatly increase the area of the attached space, resulting in a decrease in the building utilization rate. Therefore, in order to control the utilization of the building, the school could consider a ratio of 1:2 or 1:3.

Figure 3. Intention survey on proportion of male and female toilets5.2.2

5.2.2 Design problems of urinals in men's bathrooms

Due to the particularity of male urinals, I have further studied the urinals in men's toilets.

Sociological studies show that people have four levels of intimacy. Intimate contact is the distance between lovers, so according to the figure below, it is a big psychological challenge for boys to keep a close distance in urinals with weak concealing ability to conduct privacy.
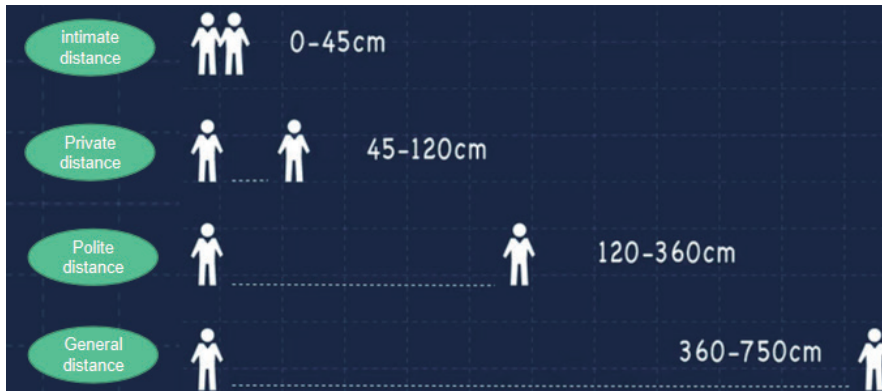

Figure 4. Classification of contact distance

We often find that boys are the most psychologically distant when they go to the bathroom, so if there are four urinals, and the first guy takes urinal number one and the second guy takes urinal number four, then the third guy doesn't have a choice.

If it's a seven-person pool, the first person takes urinal number one, the second person takes urinal number seven, and the third person takes urinal number four, then the fourth guy doesn't have a choice.

Similarly, thirteen urinals are likely to be used by only five people, resulting in a huge waste of social resources.

In this regard, I conducted a series of algorithm research, set the number of men's toilets as N, set the time for men to go to the toilet as infinite, and set the number of men that the toilet can accommodate at the same time as M. The relationship of m, n is called m=f (n). When n is odd, the first boy to choose first the urinal, the second boy to choose the first n urinal, the third guy choose the first (n + 1) / 2 urinals, namely the left can accommodate f (n + 1)/(2) the individual, the right can accommodate f ((n + 1) / 2) personal, can accommodate the number of total for both sides to subtract the sum of repeat middlemen, I get 2f of n plus 1 over 2 minus 1 person.

When n is even number, the first boy chooses the first urinal, the second boy chooses the NTH urinal, and the third boy chooses the n/ 2nd urinal. That is, the left side can hold F (n/2), and the right side can hold F (n/2+1). The sum of the accommodating capacity is the sum of the two sides and then deducting the repeated middleman, The result is f(n/2)+f(n/2+1)-1.

$$F(n) \begin{cases} f(n/2)+f(n/2+1)-1, \text{ n is an even number} \\ 2f((n+1)/2)-1, \text{ n is an odd number} \end{cases}$$
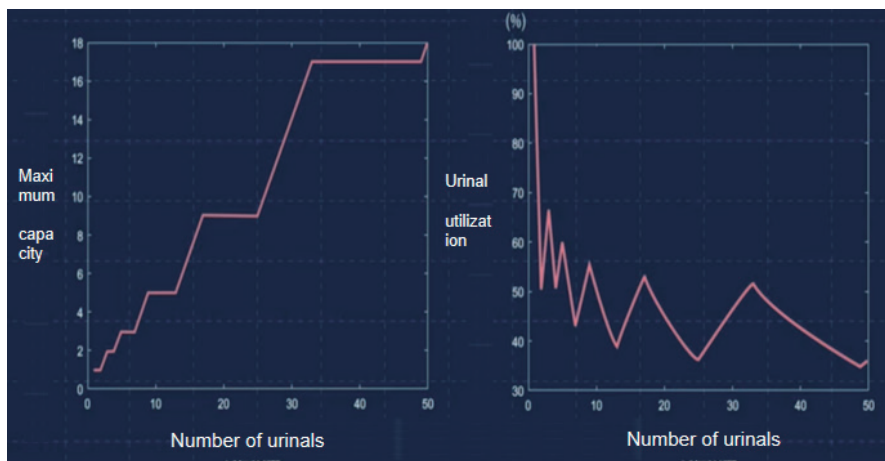
So, the functional graph is made as:

Figure 5. Function image with the number of urinals as independent variable

It can be found that, with the increase of the number of pits, the maximum capacity of toilets rises in a stepped manner, while the utilization rate of pits drops in an oscillating manner, and finally fluctuates between 1/2 and 1/3. At the same time, we can also draw the following conclusions: namely, when the number of pits is $2^K +1\sim1.5*2^k+1$, the maximum number of toilets can accommodate $2^{(k-1)} +1$, that is, when k=3, that is, the number of pits is 9~13, the number of boys can accommodate 5.

This also reminds us that men's toilet urinal does not need the more the better, as I found in the observation and research, the school the three school buildings are at 12 urinals men's room number, but in many cases, we found that once filled with 5 people, a few are willing to go to the rest of the pit, rather is one of the men on the, and 12 urinals occupy too much space, Distance between each other and small, in which clean tool is placed, and lead to students because of too close and more resistant to occupy adjacent urinals, causing the waste of resources and the result of the cleaning tool messes, therefore as function analysis, set the urinal 9 is enough, the rest of the space is used to improve the hole spacing and set cleaning tools. In order to better understand the problems caused by the design of urinals in men's toilets, I boldly assume that there is a toilet with 100 million urinals. Then it can be calculated that the toilet can hold up to 33,554,433 boys at the same time, that is, there are 66,445,567 holes left, and the waste rate is as high as 66%.

Based on the above analysis, the utilization rate of urinals in men's toilets in Settings 3, 5, 9 and 17 is the highest, while that in settings 4, 7 and 13 is the lowest.

5.2.3 Squatting problem in women's bathroom

In many larger areas of the toilet, generally will use two rows of toilets to the toilet, but this design is generally the need for a toilet room in 3.7 meters or more, and the school because of the limited area of the three teaching buildings, the use of straight layout that is, a single row along the wall layout. But because the aisle is a little long, the compartment baffle has a certain height, which brings a sense of pressure to the girls, plus the end of the space effect, this feeling will be amplified, so as to bring greater discomfort to the girls. Accordingly, go up in toilet design, had better still put apart certain building space will design two row pair to lavatory, had designed toilet to carry deep and lie between space again, can bring better experience to user and taller dimensional utilization rate

5.2.4 Humanized design of the toilet

A. Privacy design

The reason why there are partitions in public toilets is that the gap is conducive to ventilation and cleaning, preventing circulation due to blockage, and observing whether there are accidents, etc. However, the survey found that the gap of the partitions in the toilets of the teaching buildings of the school is 32cm, and the survey found that students generally think 20-25cm is appropriate, so as to reduce their concerns about privacy.

B. Privacy of smell and sound

In the questionnaire, 70% of the respondents said that other toilet waiters always stuck their bodies in the nearest place to the pit because they were afraid of being occupied in the queue. As a result, the toilet users felt that someone was watching them at the door or behind them, which greatly affected their toilet experience. At the same time, in the environment of the toilet, most people do not like to open their mouth to speak, so the overall space environment will be very quiet, coupled with the sense of urgency and irritability when waiting, then the sound and smell of the toilet will bring great embarrassment to people. Then you can play soothing light music in the toilet to relieve the anxiety of the person, and at the same time place an appropriate number of fresh green plants to purify the air and cover up the smell, while distracting the attention of the

Figure 6. Light of public toilet

waiting person.

C. Privacy of light

According to the questionnaire, students generally believe that too bright light will make users feel as if exposed to "broad daylight", resulting in embarrassing psychological feelings, such as Xiyi and Dongyi. And too dim light will make students fear and promote the occurrence of criminal acts, such as Wen Yi. Accordingly, integrated both, choose relatively downy neuter lamplight to have sense of security more.

6. Conclusion

In this study, a field survey was conducted on the west No.1, East No.1 and Liberal Arts No.1 teaching building of a university.According to the related human factors engineering psychology and environmental behavior, this paper studies the process of students' toilet behavior and their toilet psychology.We adopt comparative analysis, logical analysis, hypothesis analysis, analogy analysis, illustration analysis, summed up the toilet design of unreasonable problems or needs to be improved, and one by one analysis, put forward the corresponding solutions and related ideas, also hope to be able to bring other toilet of college teaching building design inspiration and advice.

References

[1] Guo Jianing. Emotional public toilet design research[D]. Jilin Jianzhu University, 2020.DOI:10.27714/d.cnki.gjljs.2020.000208.
[2] Zhao Zhao. Research on the design method of teaching building bathroom in Dalian[J]. *Dalian University of Technology*, 2014.
[3] Zhao Zhao. Proportion of male and female toilets in public restrooms in university comprehensive teaching buildings[J]. *Zhonghua Minju*. 2014(08): 231.