Optimization of self-study room open problem based on green and low-carbon campus construction

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Abstract. The optimization of self-study room open arrangement problem in colleges and universities is conducive to accelerate the fine management of the campus and promote green and low-carbon campus construction. Firstly, combined with the actual survey data, the self-study area and living area were divided into different blocks, and the electricity consumption in each self-study room and distance between different living and studying areas were normalized. Secondly, the minimum of total satisfaction index and the minimum of the total electricity consumption were selected as the optimization targets respectively. The mathematical models of linear programming were established and resolved by LINGO software. The results showed that the minimum of total satisfaction index was 4055.533 and the total minimum electricity consumption was 137216 W. Finally, some advice had been put forward on how to realize the high efficient administration of the study room.

1 Introduction
In recent years, electricity waste has become a very serious problem in colleges and universities, which is incarnated in the evening self study. One situation is there are a handful of students in the study room, but the lights are all turned on; the other situation is there are a few students who want to study at night, but lots of classrooms are opened. Sometimes, there is even no student in a classroom while the lights are all still lit. Therefore, it is necessary to establish an economical and reasonable management method, which is not only conducive to promote the fine management of the campus, but also conducive to promote the green and low-carbon campus construction [1-2]. Our present research interests are focused on the optimization of typical environmental problems and their effective solution methods [3-5]. In this paper, a typical self-study room open arrangement problem was analyzed and resolved by lingo software. This paper may provide a reference for the relevant departments to intensify the management solutions in colleges and universities.

2 PROBLEM DESCRIPTIONS
A classroom administrator in a university needs to open some classrooms every night from 17:00 to 22:00. If a classroom is opened, then all the lights in this classroom are assumed to be opened please complete the following questions:

(1) There are about 19,500 students in the school. Sample survey indicates that each student is independent in self study and the probability of self-study is 0.9. Assuming that students who need to self-study can be satisfied by the degree of not less than 95%, so the number of self-study students is \( 19500 \times 0.9 \times 95% = 16672 \). In order to ensure the occupancy rate of classroom is not less than 4/5,
while not more than 90%, please try to answer which classrooms should be opened, so as to achieve the purpose of saving electricity?

(2) According to the specific location of the dormitories, the living area was divided into seven blocks (S1-S7). There are 135 classrooms available for evening study. Due to the geographical location, we divided them into four areas: Z1, Z2, Z3 and Z4. Z1 represents south public teaching building, Z2 represents Lecture group and library building, Z3 represents main public teaching building B and Z4 represents main public teaching building C and D. The main public teaching building is divided into Z3 and Z4 areas, because there are a large number of self-study rooms, and the classrooms in main public teaching building B are irregular, so it is helpful for the following targeted analysis. It is assumed that the spent time from the dormitory area to a classroom is the same as that of any classrooms in the same self-study area. Give a reasonable degree of satisfaction measurement, and re-consider how to arrange the classroom, can not only achieve the purpose of saving electricity, but also improve the student satisfaction index. In addition, try to arrange to open the same district of the classrooms.

3 PROBLEM ASSUMPTIONS
The power supply is normal; there is no power outage; the probability of self-study is not affected by the weather; the light bulbs, tables and chairs are intact, and can be used normally; all the lights and seats are distributed evenly; the probability of self-study has nothing to do with the distance between the living area and studying area.

4 MODEL AND SOLUTIONS

4.1 Mathematical model for question 1 and its solution
First of all, electricity consumption in each self-study room and distances between different areas were normalized, the results are showed in Table 1 - Table 2. Then, the satisfactory function was constructed, which uses unit electricity consumption $Pn(n=1-4)$ and distance $Lmn$ as the dependent variable of the function. For unit electricity consumption and distance, we assume that the unit electricity consumption is slightly more important than the distance, so when given the weight value, we take $W= (0.6, 0.4)$. Satisfactory function was showed as: $F(Pn, Lmn)=0.6Pn0.4Lmn$ $(m=1, 2, 3, 4, n=1, 2...7)$. The data in Table 1 and Table 2 were substituted into the above formula, satisfactory function values form the dormitory area to the various study areas were calculated. For each opened classroom, we require its occupancy rate is not less than 4/5, while not more than 90%. Four study areas shou

| Area code | Z1 | Z2 | Z3 | Z4 |
|-----------|----|----|----|----|
| Unit electricity consumption $Pn /W$ | 0.399 | 0.155 | 0.243 | 0.202 |

Table 1. Normalized electricity consumption of self study room in different areas.

| Distance Lmn/km | Z1 | Z2 | Z3 | Z4 |
|-----------------|----|----|----|----|
| S1              | 0.2391 | 0.2804 | 0.2402 | 0.2402 |
| S2              | 0.2487 | 0.2841 | 0.2336 | 0.2336 |
| S3              | 0.2082 | 0.2780 | 0.2569 | 0.2569 |
| S4              | 0.2220 | 0.2824 | 0.2478 | 0.2478 |

Table 2. Normalized distance between different dormitory area and the study room area.
Table 3. Number of students calculated in the 4 self-study areas according to requirements.

|          | Z1  | Z2  | Z3  | Z4  | Sum |
|----------|-----|-----|-----|-----|-----|
| Total Seats | 2964 | 3716 | 4194 | 10440 | 21314 |
| Mn4/5   | 2371 | 2973 | 3354 | 8352 | 17050 |
| Mn90%  | 2668 | 3345 | 3774 | 9396 | 19183 |

Table 4. The number of students in seven dormitory areas

| Dormitory areas | S1  | S2  | S3  | S4  | S5  | S6  | S7  |
|-----------------|-----|-----|-----|-----|-----|-----|-----|
| Number          | 3449 | 2874 | 3874 | 3449 | 1149 | 1725 | 1149 |

Then let $M$ represent the sum of the satisfactory function:

$$M = \sum_{i=1}^{4} \sum_{n=202}^{413} X_{i,n} F(P_{i,n}, L_{mn}) \quad (m = 1-4, n = 1-7)$$  (1)

The linear functions on the objective function $M$ and the constraints can be established. The following standard form was obtained:

Objective function

$$\min M = \sum_{i=1}^{4} \sum_{n=202}^{413} X_{i,n} F(P_{i,n}, L_{mn}) \quad (m = 1-4, n = 1-7) = 0.2391X_{11} + 0.2804X_{12} + ... + 0.2853X_{74}$$  (2)

Constraints:

$$X_{11}+X_{12}+X_{13}+X_{14} \leq 3449; X_{21}+X_{22}+X_{23}+X_{24} \leq 2874; X_{31}+X_{32}+X_{33}+X_{34} \leq 3874; X_{41}+X_{42}+X_{43}+X_{44} \leq 3449; X_{51}+X_{52}+X_{53}+X_{54} \leq 1149; X_{61}+X_{62}+X_{63}+X_{64} \leq 21314; X_{71}+X_{72}+X_{73}+X_{74} \leq 17050;$$

$$1 <= X_{11}+X_{12}+X_{13}+X_{14}+X_{15}+X_{16}+X_{17} <= 2668; 2973 <= X_{21}+X_{22}+X_{23}+X_{24}+X_{25}+X_{26}+X_{27} <= 3354; 3355 <= X_{31}+X_{32}+X_{33}+X_{34}+X_{35}+X_{36}+X_{37} <= 3774; 8352 <= X_{41}+X_{42}+X_{43}+X_{44}+X_{45}+X_{46}+X_{47} <= 9396; 9396 <= X_{51}+X_{52}+X_{53}+X_{54}+X_{55}+X_{56}+X_{57} <= 1149;$$

The above linear programming problem can be resolved by LINGO 11.0. The minimum value of the satisfactory functions index is 4055.533.

4.2 Mathematical Model 2 for question 2 and its solution

The total number of seats required for each study room area can be calculated from the results of Model 1, which is $Z1=2371$, $Z2=2973$, $Z3=3854$, $Z4=8854$. In order to obtain the minimum value of the total electricity consumption, the mathematical model of the four study areas can be established respectively. For mathematical model for $Z1$ area, the linear programming model was established as follows,

Objective function

$$\min Z1 = \sum_{i=202}^{n=413} P_{i}X_{i} - 1104X_{n202} + ... + X_{n413}$$  (4)

Constraints:

$$178X_{n202}+178X_{n205}+126X_{n206}+126X_{n207}+126X_{n208}+172X_{n212}+126X_{n302}+178X_{n305}+126X_{n306}+126X_{n307}+126X_{n308}+126X_{n309}+126X_{n310}+172X_{n313}+178X_{n403}+178X_{n406}+126X_{n407}+126X_{n408}+172X_{n412}+172X_{n413} >= 2371$$  (5)

$$X_{i} = 0 \text{ or } 1 \quad (i=n202, n205...n413)$$  (6)

The results were obtained by LINGO 11.0 software: the classrooms in the south public teaching building area should all be opened except 208, 212, 302, 306 and those classrooms on fifth floor, when the minimum electricity consumption of $Z1$ area is 32240 W. Similarly established were the
Mathematical Models for Z2, Z3 and Z4 area, the minimum electricity consumptions were 12672, 31104 and 61200 W respectively. The total minimum electricity consumption can be calculated through the above optimized results, which was 32240 +12672 +31104 +61200 = 137216W.

5 CONCLUSIONS AND PROSPECT
Based on the above optimized procedure, the open response system software of self-study room open arrangement can be designed. Once college students input their preferred time and location of self-study into the computer, the system can automatically output the optimal results to meet the requirement based on the software calculation. The operations of the software will be helpful to improve the utilization efficiency of the classrooms, thereby promote low-carbon campus construction. Additionally, energy-saving lamps should be vigorously popularized, which may solve the campus waste of electric power greatly. As far as we know, energy-saving lights cost less money in the process of using than normal fluorescent lamp. What’s more, reasonable campus planning, humanized distribution and distance of teaching building and dormitories can not only make the learning more comfortable, but also promote campus energy conservation.

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