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Research on Optimization of Intelligent Express Locker: In the Case of the Intelligent Express Locker in S University

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Abstract
Take postal intelligent express locker in S university as the research object, through field visits, analysis of the use of the intelligent express locker working for the last mile of S university, finds out the existence problems of lack of humanization design. According to the methods for engineering optimization, proposed bin for the layout and design optimization area, etc.. The implementation of the new scheme makes the intelligent parcel delivery terminal intake capacity increased by 89%, also, the operation of the regional settings more humane.

Key words: Ecommerce logistics; Intelligent express locker; Ergonomics; Layout optimization

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INTRODUCTION

As the rapid development of China's economy and e-commerce, electric business logistics industry ushered in the golden period of development. Perfect and efficient e-commerce logistics system, which providing strong support, is the basis for the development of electric business (Rao, 2014). Currently in China, there are three kinds of electric commerce logistics distribution mode, self-support logistics, third party logistics and self-support combined third party logistics mode. But no matter what kind of logistics mode enterprise using, they are still faced with the problem of the last mile distribution (Wang & He, 2003; Wen & Yu, 2009; Tang & Chen, 2013). The main problems of the last mile distribution are focused on the problems of high cost, low level of service, no guarantee of the safety of goods, inconvenient of distribution, imperfect in public infrastructure, low degree of informatization and so on. In order to solve the long-time last mile delivery problem, the domestic researchers focused more on how to change the operation mode but not on how to improve technical equipment. Many of the express logistics facilities are rather old, with relatively low level of electronization, which cannot meet the requirement of rapid development of e-commerce logistics. The key to solve the problem is to use new technologies and new equipment, to develop of intelligent courier cabinet, and finally to reach the end of guaranteeing consumer safety, convenience, privacy requirements, as well as reducing the cost of the last mile distribution in the long run.

The electronic business intelligent express cabinet now has been widely used domestic and abroad. In America, the Amazon Co launched a smart courier cabinet called Amazon locker; in Canada, an express company specializing in last mile distribution provides an intelligent courier cabinet named Buffer Box, which was used by UPS; Germany DHL launched the Pack-station is also a form of intelligent express cabinet which provided self-service pick up service; Poland post supplies self-service parcel picking cabinet called Easy Pack (Zhao & Zhu, 2013; Hong, 2014). Eleonora et al. (2014) did research on the alternative parcel delivery service (pick-up point in stores and automated lockers network) in France and Germany, and found both of these delivery service making important impact on e-commerce final

deliveries. As for China, up to September 2016, Chinese post, SF, some of the third party logistics company, as well as Amazon China, JD.COM and some other logistics technology enterprise have launched intelligent express locker, but there are still not much research on this area in China. Zhang et al. (2015) compared with the "Cainiao Yizhan" and "Feng nest" smart courier cabinet model, finding the advantages and disadvantages and put forward some suggestion for the two models. Wang et al. (2016) did research on the smart express locker development situation in Zhuhai, and found out the problems in the development of intelligent express cabinet and put forward the future strategies. Smart express cabinet is a kind of self-service device for express delivery and send. It has appeared in China's e-commerce courier market for nearly four years. The State Post Bureau also issued the standard file "smart express box" in September 2013, but the file did not make it clear what the courier cabinet box size is, or what rules to obey when design the locker. At present, the theoretical research on the intelligent express cabinet is in the blank stage.

Human factors engineering is a relatively young, independent and unique practical discipline, and its research and application focus on military, industrial human factors engineering, consumer products and services, computer human factors engineering, etc. After more than 50 years of research and application, human factors engineering has developed its own unique application technology, that is, "human-machine interface technology" (Hendrickz, 1999). Human–machine interface technology has been developed into four branches: Hardware human engineering, environmental human factors engineering, cognitive human factors engineering, and human factors engineering. Among them, the hardware engineering initially studied of human physiological and intuitive characteristics, and its related results applied to the operation, display and analysis of the layout of the work space, design and evaluation of the process (Liu, Qi, & Yang, 2002). Therefore, the application of human factors engineering can be used to optimize the intelligent courier cabinet.

This study selected a smart courier cabinet in the S University as the research object, and applied hardware human factor engineering technology to redesign the locker size and the layout of the smart express courier, hoping to provide a reference for the standard establishment of a smart courier cabinet.

1. ANALYSIS ON THE PROBLEMS OF THE CAMPUS INTELLIGENT EXPRESS CABINET

For a long time in China, university students have to pick up their express packages on the centralized distribution point where the courier found and pores the packages on. There are no lockers for students to receive their packages. This model of delivery causes many problems, such as low service level, packages missing, limited delivery time, disordered management and so on. As university student is a big consumer group, e-commerce enterprise and express delivery company should focus on how to improve the long-standing problems.

1.1 Application Status of Smart Courier Cabinet in S University

1.1.1 Last Mile Delivery Situation of S University

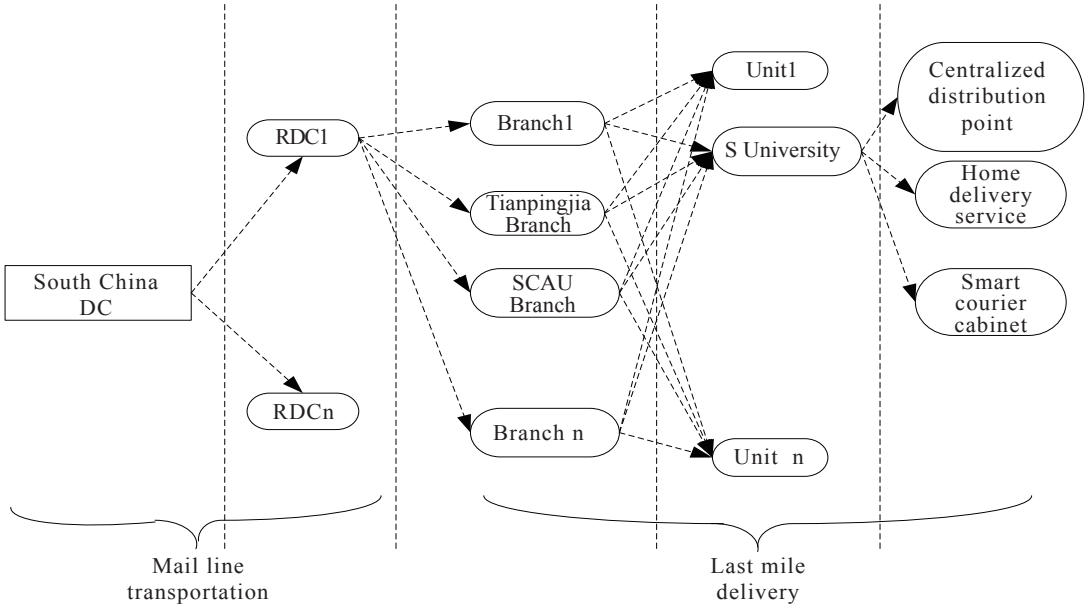

Figure 1
Sketch Diagramp of the Last Mile Delivery of S University

For now, there are three kinds of package delivery service in S university. The first kind of service is door-to-door delivery. For some certain shopping platform, like Yihaodian.com, commodities would be delivered to the gate of the students' dorms. Many students show high satisfaction of this kind of high level delivery service, but it costs more of the courier fee. The second kind of service appears commonly in universities is delivery to centralize distribution point which was chosen by courier randomly. This kind of delivery service costs relatively low but causes many problems like package missing, second time delivery and so on. Unfortunately we found 91.43% of student was suffering from this problem. The third and newest kind of delivery service appears recently is delivery through smart courier cabinet. Setting this kind of intelligent courier locker may cost high installation fees at the beginning, but later operation fee would be lower. Students preferred the third kind of service than the second one. There is a few smart courier locker in S university. One is operating by the Chinese postal, and the other is operating by a third party logistics technology enterprise.

1.1.2 Application Status of Smart Courier Cabinet in S University

In this study, an intelligent express cabinet in S university is taken as an example. The appearance of this smart courier cabinet is a white locker, and there are three kinds of specifications of the box size. One of this cabinet can contain 19 boxes of packages. The operation of the touching screen is located in the middle of the cabinet, there are two generation ID card scanning sensing area under the touch screen, which is used to scan the ID card information, and there is a bar code scanning port next to the sensing area.

Using process of this kind of smart courier cabinet is as below: After students bought goods from Taobao.com and chose some certain express enterprise which was cooperated with this kind of last mile delivery service, courier would put their packages into the locker after they arrived. And then the smart locker terminal would automatically send out a message with pick-up code to the recipients' cell phone. The recipient needs to take out their package within 48 hours, whenever they are free. To finish a deliver process, courier should swipe their ID card as well as the bar code of the package in the scanning area, and then chose which size of box to occupy. When the door of the blank box open, they put the package in, close the door and finish a delivery. After receiving the pick-up code message, the recipient chooses pick-up function on the operation screen, then swipe their ID card and input the code according to the instruction. Then the door of the certain box would open automatically, so that the recipient could easily take out the parcel, which finishes a receiving process. 75.24% of students would like to use this smart courier cabinet in S university.

1.2 Layout Problem Analysis of the Intelligent Express Cabinet

In this study, the intelligent express cabinet only has a storage function, with simple hardware design. After a period of time of observation, we found that the size design of the lockers had make the utilization efficiency low of the locker space. And the whole cabinet design did not conform to ergonomics requirements.

(a) The size of the lockers were not reasonable, which made the whole cabinet could arrange nineteen lockers only currently. The space utilization rate of the current cabinet was not high enough. As research, this cabinet had three kinds of locker sizes, which showed as in the below Table 1.

Table 1
Box Size of the Current Cabinet of S University
(Unti: mm)

Locker size	Width	Depth	Height
S	400	400	180
M	400	400	230
L	400	400	400

(b) Both the height of the cabinet body and the control screen was too high, which did not meet the requirement of ergonomics. It was not easy as well as convenient to reach for some petite students like girls, which reduce the customer satisfaction.

2. INTELLIGENT EXPRESS CABINET OPTIMIZATION CONCEPTUAL

2.1 Intelligent Express Cabinet Locker Size Optimization

The study refer to postal carton size first, which showed as below Table 2:

Table 2
Carton Specifications of the Post Office (Unit: mm)

Carton No.	Length	Width	Height
1	530	290	370
2	530	230	290
3	430	210	270
4	350	190	230
5	290	170	190
6	260	150	180
7	230	130	160
8	210	110	140
9	195	105	135
10	175	95	115
11	145	85	105
12	130	80	90

This paper intends to design three kinds of specifications of the locker size, which is large, medium and small size. And the quantitative proportion of the three size lockers should be roughly 20%, 30% and 50%.

This conceptual design process is under the following principles:

(a) Oversized cartons like cartons No. 1, No. 2 would not be considered;

(b) The large size of the locker should be able to accommodate cartons No.3 and 4; the middle size of the locker should be able to accommodate the No.5-7 cartons; and the small lockers can contain No.8 to 12 postal carton;

(c) Each locker should be designed with a surplus space so people could access to the package easily;

(d) Different sizes of the three specifications of locker vary in height, but same in width as well as depth.

According to the above principles, this study refers to domestic and foreign intelligent courier cabinet size, and considers the production process to be convenient, different sizes of the three specifications of locker vary in height, but same in width as well as depth. Locker of smart courier cabinet that existed home and abroad usually has a depth dimension from 200 mm to 600 mm, and 250 mm to 450 mm in width dimension. The biggest boxes of the postal carton are No.3, 430 mm in length, 210 mm in width and 270 mm in height. Considering production reference easily, people usually make it an integer value in size, so the depth of the locker is 450 mm, and the width is 300 mm. We can also find that, the small size locker, which used to accommodate No.8 carton, should be higher than 140 mm; similarly, the middle size locker should be higher than 190 mm and the large locker to be higher 270 mm. The final optimization conceptual of each specification of the three kind of locker shows as Table 3.

Table 3
Locker Size Optimization Conceptual (Unt: mm)

Locker size	Width	Depth	Height
S	300	450	150
M	300	450	200
L	300	450	300

2.2 Layout of the Effective Operation Area of the Intelligent Express Cabinet

Storage space can be roughly divided into five interval scale: The first interval scale is 59 cm to 124 cm, in which area people can get things out of the locker easily in the standing posture. The second is 124-153 cm, in this area, people should hands up over their shoulder to get the object. The third area is 30-59 cm, people should bend or squat to reach the objects. The forth area is higher than 153-188 cm, people might raise their hands to reach an area which is higher than themselves. And the fifth area is 0-30 cm, people need to squat or they can't take out the object from the shelf. The scale division of storage space showed in Figure 2 (Zhang, 2012).

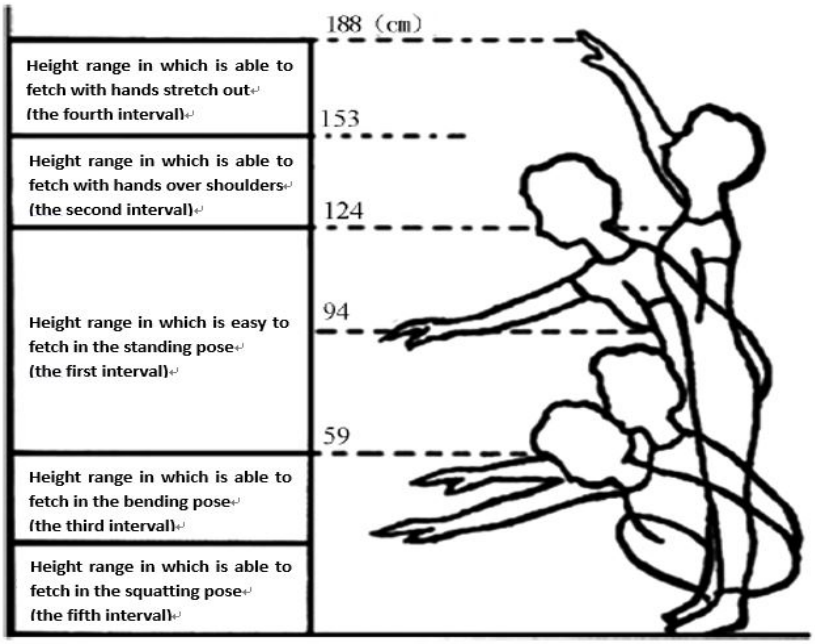

Figure 2
Scale Division of Storage Space (Zhang, 2012)

Different height levels have different scale of vision when people are in the standing posture. With 200 mm as the size of the differential, according to the standing state of visual coverage can be divided into three intervals: assume a 150 cm-high person standing 40 cm away to the storage cabinet, the scale that he can see a small portion of the inside of the locker ranges from 0-120 cm; the scale that he can see a large portion of the inside of the locker ranges from 120-180 cm. When he looks up, he can see a little portion inside the locker ranges from 180-200 cm (higher than 200 cm is out of consideration). People standing vision range was shown in Figure 3.

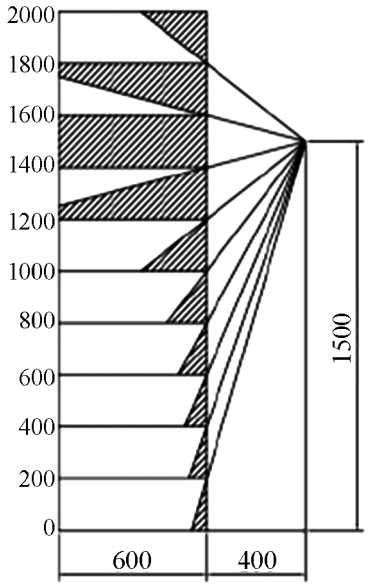

Figure 3
Standing Vision Range (Zhang, 2012)

According to the above discussion, the optimization conceptual divided the storage area of the cabinet into four parts according to the convenient level of operation. Area A is the best operation area, ranges from 120-150 cm, area B ranges from 59-120 cm, area C ranges from 30-59 cm, area D conclude area higher than 180 cm and the lower than 30 cm areas. Storage area division of the smart courier cabinet showed as in Figure 4.

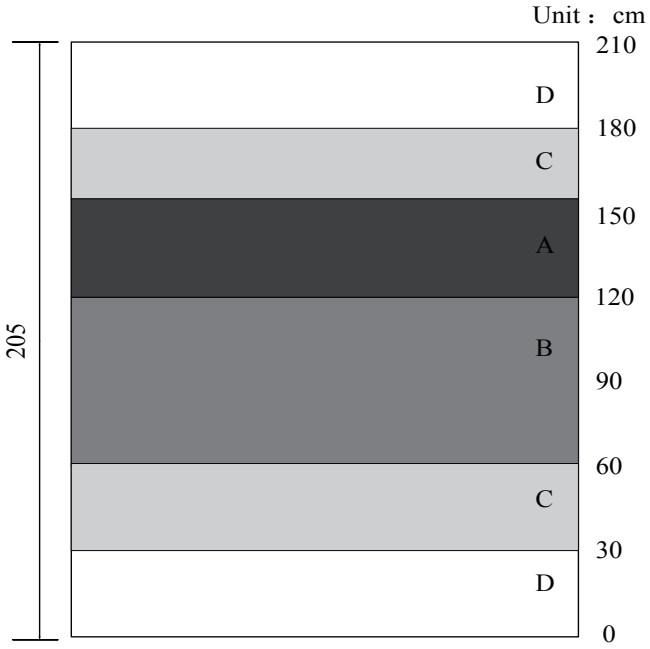

Figure 4
Storage Area Division of the Smart Courier Cabinet

From the ergonomic point of view, the most easily accessible places should be set up the most commonly used components, so as to make the machine more humane, improve work efficiency, and reduce fatigue (Lu, Xu, Lai, & Hua., 2009). According to the analysis of the frequency of use and the efficiency of different regions, the layout of the box should be improved as follows:

(a) Area A is the best operation area of the whole cabinet, so it is the best to accommodate all the three specifications of boxes in area A. But the area is small, and here in the study we consider A and B together to be the best operation area. This best operation area should contain all the three specifications of boxes as it's of highest utilization. And area C, the better operation area,

is accommodated with boxes that of higher utilization as supplement;

(b) The quantitative proportion of the three size boxes should be roughly 20%, 30% and 50%;

(c) There must be a gap between the boxes;

(d) Area D should cover all kinds of boxes that to be use for emergency. When courier delivery packages, boxes in area A and B would be used in the highest priority, then boxes in area C and final D.

According to the above improvements, the final layout of the intelligent express cabinet was showed in Figure 5:

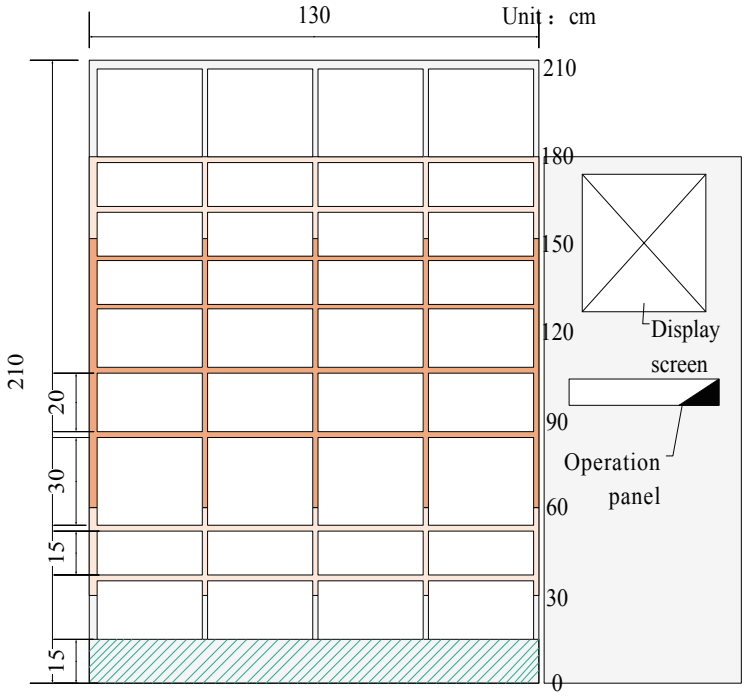

Figure 5
Optimized Layout of the Smart Express Cabinet

This best operation area contained all the three specifications of boxes as it's of highest utilization. The gap between two adjacent edges of each box is 2 cm, and at the same time, the conceptual had separated from the storage area and the operation area, which made it more flexible of the capacity of the cabinet. The optimized cabinet took into account the principle of efficiency and beauty, which improve the customer satisfaction level.

3. IMPACT ASSESSMENT OF THE OPTIMIZED CONCEPTUAL

3.1 Capacity Increased After the Optimization

(a) The whole cabinet could accommodate more types of packages: the depth of the cabinet is 45 cm after optimization, which made the cabinet to be able to hold more sizes of the postal parcels.

Table 4
Comparison of Overall Size Before and After Optimization (Unit: cm)

	Overall size before	Overall size after
Height	210	210
Width	130	130
Depth	40	45

(b) The number of packages increased in the same volume of cabinet: The lockers can be accommodated more than 85% of the postal boxes after optimization. And each locker was designed with a surplus space so people could access to the package easily. The same volume of the cabinet can accommodate the packages rose from 19 pieces to 36 pieces, which increased by 89.47%.

Table 5
Comparison of the Box Size Before and After Optimization (Unit: cm)

	Before			After		
	Height	Width	Depth	Height	Width	Depth
L	40	40	40	30	30	45
M	23	40	40	20	30	45
S	18	40	40	15	30	45

3.2 After the Optimization of the Layout of the Box Area Operation Area More Humane

After the optimization of the layout of the box is more in line with the requirements of human engineering, the most convenient operation of the human body in the area set up a variety of specifications of the box, the average consumer can easily remove the highest layer of the box in the package.

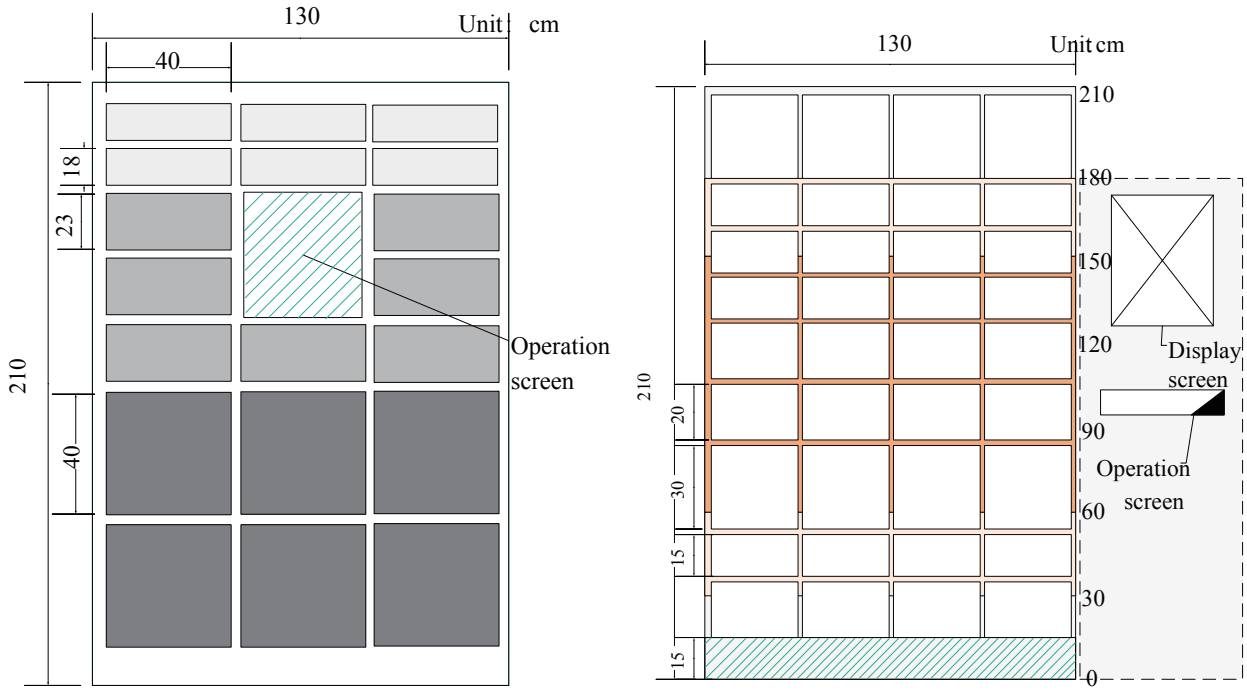

Figure 6
Comparison of the Layout of the Smart Express Cabinet

3.3 Improve Customer Satisfaction

After redesigned, the smart courier became more humanization. Through promotion, more and more students are willing to use this new type of distribution equipment, making the smart courier cabinet is no longer a decoration by raising its use frequency. Moreover, the optimization and improvement of intelligent express cabinet are more in line with the requirements of human engineering, users will feel more comfortable and convenient.

CONCLUSION

The study took postal intelligent express locker in S university as the research object, through field visits, analyzed of the use of the intelligent express locker working for the last mile of S university, finding out the existence problems of lack of humanization design. According to the methods for engineering optimization, proposed bid for the layout and design optimization area, etc.. The implementation of the new scheme makes the intelligent parcel delivery terminal be able to accommodate more than 85% of the postal boxes, which intake capacity increased by 89%, as the same volume of the cabinet can accommodate the packages rose from 19 pieces to 36 pieces. Also, the operation of the regional settings more humane.

The theoretical research on the intelligent express cabinet is in the blank stage. This study only relates to the size design of ergonomics optimization, and there still needs to do a lot of research in equipment design, location planning, operations and so on. To use Smart courier cabinet in the last mile delivery as a supplement to the traditional distribution methods, helps to improve the last mile delivery efficiency and reduce the cost of the last mile distribution. Regional environment of universities is suitable to promote this kind of delivery method.

REFERENCES

Eleonora, M., Saskia, S., Corinne, B., Laetitia, D., & Barbara, L. (2014). The impact of e-commerce on final deliveries: alternative parcel delivery services in France and Germany. *Transportation Research Procedia, 4,* 178-190.

Hendrickz, H. W. (1999). *Ergonomics: An international perspective*. CRC Press.

Liu, C. R., Qi, Y. S., & Yang, M. Z. (2002). Human factors engineering in modern manufacturing systems. *Mechanical Design and Manufacturing Engineering*, (01), 45-47.

Lu, D. M., Xu, X. J., Lai, C. A., & Hua, B. (2009). Discussion on notebook keyboard layout using human factors engineering. *Industrial Engineer*, (01), 88-91.

Rao, S. L. (2014). Research on optimization of e-commerce logistics system. *Logistic Technology*, (01), 175-177.

Tang, Y. F., & Chen, H. B. (2013). Research on the distribution mode of network terminal in the e-commerce environment. *Information Technology*, (05), 92.

Wang, D. L., & Yu, Z. N. (2016). Research on the development of intelligent express cabinet under the background of smart city—Taking Zhuhai as an example. *Logistics Technology*, (05), 25-28.

Wang, D. P., & He, H. Y. (2003). Research on the development of e-commerce logistics in China. *Industrial Engineering*, *6*(02), 29-31.

Wen, G. L., & Yu, B. (2009). Research on logistics distribution mode of e-commerce. *China Logistics and Purchasing*, (21), 74-75.

Zhang, H. Y., & Shang, X. (2015). Analysis of express industry in the last mile distribution pattern—Taking as an example and rookie Inn Feng nest. *Transportation Manager World*, *22,* 48-51.

Zhang, L. X. (2012). *Research on modular design and application of storage furniture in screen office space*. Nanjing Forestry University.

Zhao, X., & Zhu, J. (2013). Preliminary exploration of the express delivery cabinet. *Logistics Technology*, (9), 33-35.

