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Innovation of Campus Express Terminal Delivery Mode during the COVID-19 Pandemic

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ABSTRACT
The overlapping effects of epidemic prevention and control measures and the development of online shopping have exposed various problems that already exist in the campus express terminal delivery. There are two requirements, one is optimizing the operation processes of the on-campus post station, and the other one is increasing the unmanned delivery mode. In this study, a new on-campus express terminal delivery solution was reconstructed, which included inbound and outbound processes, and integrated the two pickup modes of unmanned delivery and self-pickup. Simulation experiments were conducted on Flexsim simulation platform. The experimental results show that the inbound work of all-day parcels can be completed within four hours, and the unmanned vehicle can complete a delivery process in about 15 minutes. The delivery solution rationalises the operational process and improves operational efficiency, and has a certain degree of rationality and feasibility.

Keywords: *COVID-19 Pandemic, campus express terminal delivery, unmanned delivery, Flexsim*

1. INTRODUCTION

In the context of the serious epidemic，strict control measures and growing numbers of packages have created serious conflict. On the one hand, with the rapid development of e-commerce, the amount of online shopping by college students has increased, and the volume of packages into campus is growing steadily. On the other hand, the confusing situation of campus delivery and pick-up has been aggravated by the closed campus prevention and the limited resources of the on-campus post. Students cannot go out of campus to pick up express packages [1], and have to go to the express service station on campus, which leads to a large number of people gathering and long queues [2]. When the express service station is out of stock, it cannot accept following packages. The courier can only "set up a stall" out of the campus gate and wait for pickup. These phenomena not only reduce the efficiency of express delivery, but also pose huge security risks. Therefore, it is necessary for express delivery companies and university administrators to work together to comprehensively manage chaos and build an efficient, safe and economical campus express terminal delivery system.

Huang [3] summarized some typical problems of express delivery services in colleges and universities, including high demand for express delivery, few express companies covered by campus supermarkets with fixed business locations, limited pickup time, and slow pickup efficiency. Liao [4] combined the requirements of epidemic prevention and control, and put forward suggestions for improving the layout of express service stations, optimizing the distribution system, optimizing the express delivery platform, and adding distribution center equipment. Ying [5] constructed a campus logistics service station based on the common distribution theory, and verified its effectiveness with simulation technology. Each region and each universities have its own actual situation [6], so the terminal delivery scheme of express delivery on campus should be studied in combination with specific cases. In this paper, taking the main campus of a university A in Beijing as an example, through visits and questionnaires, the problems existing in the express delivery terminal is analyzed, solutions is proposed, and validated on the Flexsim simulation platform.

2. PROBLEM DESCRIPTION

2.1. Express Delivery Time

The schedule of delivery for the campus A is shown in Table 1. Students have to pick up their deliveries at break between classes in the midday and evening hours. Besides, the remaining uncollected deliveries are handed over to the campus post for temporary storage via shelves or delivery lockers.

Table 1. Express delivery time around campus A

Express Name	Schedule of delivery
Zhong tong, Yuan tong, Shen tong	Working day： AM: 11:40-12:30, PM: 4:40-5:40； Weekend：AM: 12:00-PM :1:00
Yun da	Working day： AM: 11:40-12:30, PM: 4:40-5:40； Weekend： AM: 12:00- PM :1:00, PM: 5:00-6:00
Jitu	Working day：AM:11:40-12:30
Jing dong	Working day： AM:11:40-12:30, PM:5:00-6:00； Weekend: time indeterminacy
EMS	Working day： AM:11:40-12:30, PM:5:00-6:00； Weekend：PM:5:00-6:00

2.2. Operation of Campus Delivery Station

The campus in this case covers an area of 325 acres, and about 8,000 students and teachers live or work here. There is an express service station at the north entrance of the campus, including three sets of express cabinet, an indoor courier service station and a temporary courier warehouse. Small pieces of courier will be put into courier lockers, while large pieces as well as irregularly shaped parcels will be put into the shed. A text message will be sent to the addressee. The whole area of the station is approximately 40 square metres. Three express cabinets occupy a large area, and the warehouse is a simple shed covering an area of about 15 square metres.

2.3. Demand Survey for Delivery Services

The survey was targeted at students studying and living on the main campus. The questions covered satisfaction and perceived problems with the courier service station on this campus, and four optimisation measures were also proposed for selection (two out of four), namely piloting unmanned courier delivery, increasing the number of courier lockers on campus, optimising the courier sorting process at the stations and extending the courier waiting time. A total of 120 questionnaires were distributed and 104 were returned, of which 99 were valid. Among the respondents, freshmen, sophomores and juniors account for 33%, 29% and 23% respectively. A total of 15% are senior students and postgraduate students.

From the survey results, it can be seen that 60% of students receive more than 20 packages per semester, and only 10% of students receive less than 10 packages. Most students tend to pick up their packages at midday. Due to the limited capacity of the station, a large number of packages are “staged” outside the campus gate, with only one courier waiting for picking up. Concentrating on picking up is more prone to problems such as plague transmission, loss of items, arguments, long waits and low satisfaction. Packages that are not picked up in time need to be deposited at the courier service station on campus to wait for a second dispatch, with an average pick-up time of about 5-15 minutes.

Then, the questionnaire data is analyzed by SPSS, based on ANOVA, as shown in Figure 1. The grade factor does not have a significant effect on the demand for optimised courier service stations (p>0.05); the number of packages collected per semester has a significant effect on the demand for optimisation, so the original hypothesis is rejected (p<0.05); the interaction between the two factors also does not have a significant effect on the demand for optimisation (p>0.05).

Tests of inter subject effects

Dependent variable: Optimization project

Source	Quadratic of model III	df	Mean square	F	Sig.
Corrected model	1199.231[a]	16	74.952	2.537	.003
Intercept	6547.879	1	6547.879	221.609	.000
Couriers per semester	481.705	3	160.568	5.434	.002
Grade	72.897	4	18.224	.617	.652
Couriers per semester *Grad	110.385	9	12.265	.415	.924
Error analysis	2422.850	82	29.547		
Summation	21289.000	99			
Summation of corrected	3622.081	98			

a. R^2 =.331 (Adjust R^2 =.201)

Figure 1 Tests of inter subject effects

Next, specific optimization demand of delivery modes is considered. In SPSS, as shown in Figure 2, the two-digit numbers under “Optimization Requirements” in the header represent pairs of four optimization measures. As shown in Figure 3, according to the chi-square test P< 0.05, the null hypothesis is not rejected. Students who receive different numbers of couriers per semester have a significant impact on the specific optimization needs. Based on the above analysis, a new on-campus delivery station operation process and unmanned distribution system are designed, and simulation modelling is carried out.

The number of couriers per semester* optimization demand

Couriers per semester		Optimization demand				
		12	13	14	23	24
0-5 couriers	Count	0	3	0	0	0
	Count of expectation	.5	1.4	.2	.7	.1
	Summation %	0.0%	3.0%	0.0%	0.0%	0.0%
6-10 couriers	Count	1	3	2	2	0
	Count of expectation	1.3	3.6	.5	1.9	.2
	Summation %	1.0%	3.0%	2.0%	2.0%	0.0%
10-20 couriers	Count	2	7	2	10	2
	Count of expectation	4.5	12.7	1.7	6.8	.8
	Summation %	2.0%	7.1%	2.0%	10.1%	2.0%
20+ couriers	Count	13	32	2	12	1
	Count of expectation	9.7	27.3	3.6	14.5	1.8
	Summation %	13.1%	32.3%	2.0%	12.1%	1.0%
Summation	Count	16	45	6	24	3
	Count of expectation	16.0	45.0	6.0	24.0	3.0
	Summation %	16.2%	45.55	6.1%	24.2%	3.0%

Figure 2 The number of couriers per semester* optimization demand

Chi-square test

	Number	df	Sig.
Pearson Chi-square	31.902	15	.007
LR	31.331	15	.008
Linear combination	2.392	1	.122
N in valid cases	99		

Figure 3 Chi-square test

3. SIMULATION AND MODELING

3.1. Campus Express Terminal Delivery Service Process

Based on the survey results, the workflow of the on-campus courier station is reorganized. The main process is divided into two parts: import and export process as shown in Figure 4.

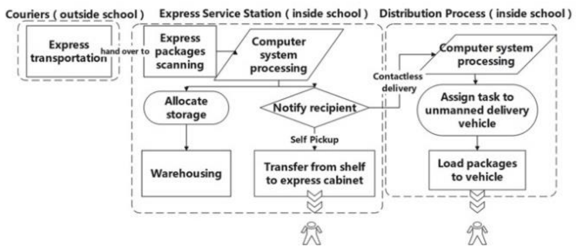

Figure 4 Campus express terminal delivery service process

During import process, station staffs receive the package, scan the package bill, and load on the racks. The computer system automatically assigns a suitable storage space to the package, and at the same time sends a message to the recipient to inquire about its pickup method (smart cabinet self-pickup or unmanned vehicle delivery and delivery time and address). According to the needs of the recipient's return, the system assigns tasks to the station staff to place packages into the cabinet, or into the unmanned delivery vehicle. The unmanned vehicle delivery route is a loop connecting the four dormitory buildings (the post station → dormitory W4 → dormitory W5 → dormitory W2 → dormitory W3 → post station), with length of about 880 meters.

Based on the above operation process, the layout of the post station is rearranged, as shown in Figure 5. The courier hands over packets at the back door and does not enter the campus. Shelves include two small parcel racks and one large parcel rack. The express cabinet is set outside the door of the station, which is convenient for the students to pick up the packages at any time. On the south wall of the station, there is a small door specially opened for unmanned delivery vehicles. Inside the wall, there is a parking area with corresponding charging equipments.

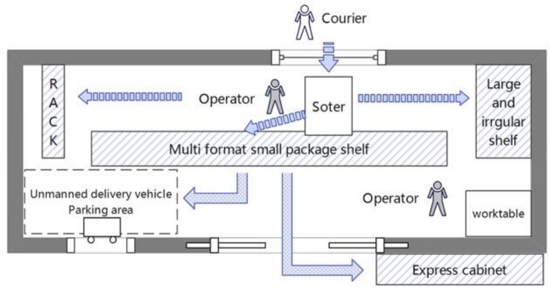

Figure 5 The remodelled layout of express service station

3.2. Modeling and Results

On the Flexsim simulation platform, the delivery mode process is modelled as shown in Figure 6. The model of the station is shown in Figure 7.

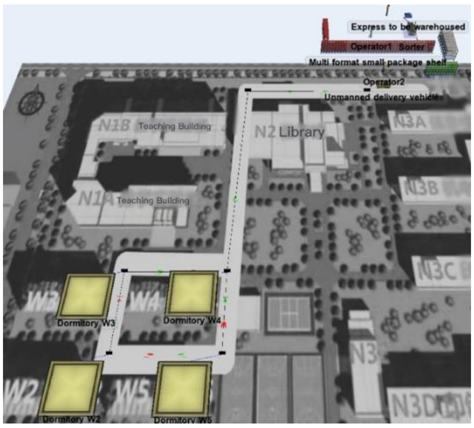

Figure 6 Global model

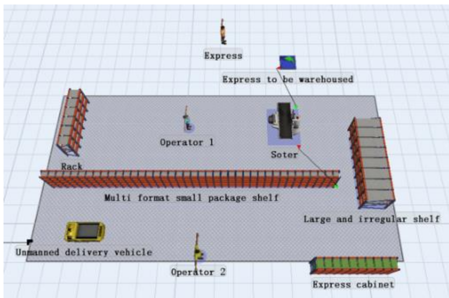

Figure 7 Model of station

The simulation results show that it takes 1810 seconds (about 30 minutes) for all 100 parcels to be put into the warehouse. Figure 8 shows that the work efficiency of personnel is relatively reasonable, and the potential capacity of the equipment is still very large. The station can deal with about 800 parcels per day on average, and all the warehousing work can be completed in about 4 hours.

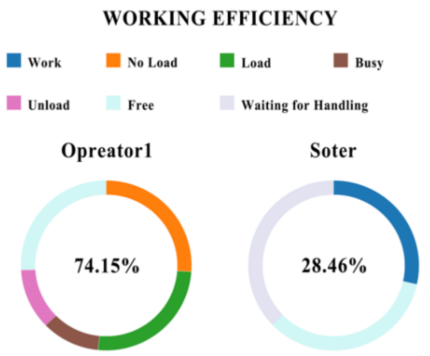

Figure 8 Working efficiency

In addition, the unmanned delivery process is also simulated. The task list is shown in Table 2.

Table 2. The unmanned delivery task

Package index	Address	Package index	Address
1	W4	6	W2
2	W5	7	W4
3	W3	8	W3
4	W2	9	W3
5	W4	10	W2

The simulation model reproduces the distance and steering of the real route. The experimental results show that regardless of the waiting time of the unmanned vehicle at the delivery destination, it takes 912 seconds (about 15 minutes) to finish this task.

4. CONCLUSION

Optimising and standardising the campus express terminal delivery mode can achieve a "three wins" situation in terms of safety for university management, efficiency for couriers and convenience for recipients. Based on a survey of the campus delivery service demand, an optimisation plan is proposed, modifying the layout of the express station and adding unmanned delivery as one of the pick-up methods. In the new campus express terminal delivery mode, all incoming parcels are uniformly sterilised, sorted and stored at the station, and then either arranged for unmanned delivery or entered into the self-service lockers according to the recipient's needs. The computer system is able to intelligently arrange reasonable delivery tasks based on the volume, address and time of the unmanned deliveries. The staffs at the station only need to move the parcels and start the unmanned vehicles according to the requirements. Afterwards, the new operational process is simulated on the Flexsim simulation platform, which shows that 800 packages could be handled within four hours, and the unmanned vehicle could complete a delivery process in about 15 minutes. The simulation experiment verifies the reasonableness and feasibility of this campus express terminal delivery mode. In future, the surge of packages in "Double 11" will be taken into account to further research.

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