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The Impact of Spatial Configuration and Functional Layout on Evacuation Efficiency of Kindergarten Activity Units

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Abstract

The kindergarten activity unit is the main space for children's daily life and learning, and also represents a special type of densely populated public building. Its layout and evacuation design play an important role in ensuring children's safety and improving evacuation efficiency in emergency situations. Therefore, our study aims to achieve a paradigm shift in kindergarten evacuation research, from the discrete analysis of evacuation 'components' (such as corridors and entrances) to integrated analysis of the 'activity units' as a whole system. As a complete evacuation analysis unit, the focus is on exploring the coupling mechanism between its internal spatial configuration and functional block layout, in order to improve evacuation efficiency. The results showed that when the classroom and dormitory of the activity unit are compared, the reasonable location for the exit of the classroom and dormitory can shorten the average evacuation time by 13.84%. When classrooms and dormitories are separated, it is necessary to control the connection exits between the classrooms and dormitories as well as the independent exits of the classrooms. This can significantly reduce the average evacuation time. The results of this study will help improve the survival ability of children in emergency situations, ensuring their safety and well-being.

Keywords: activity units in kindergarten; evacuation efficiency; space combination mode; furniture layout; simulation modeling

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1. Introduction

1.1. Backgrounds

The advancement of global urbanization has expanded and deepened the allocation of educational resources; it has also increased the number of kindergartens [1], which became an institution undertaking the key functions of early enlightenment and daily care for children. Meanwhile, safety incidents in kindergartens persist [2]. For instance, in 2019, a fire at the Harris Family Daycare in the United States claimed the lives of five children [3]. Therefore, the safety of kindergarten buildings and the efficiency of evacuating young children during emergencies need to be considered while accelerating the construction of kindergartens. The level of children's safety protection is not only a key indicator for measuring the effectiveness of the social public security system but also a core measure for assessing the degree of social civilization and the well-being of the

people. Owing to the limitations of their physical and mental development, young children possess insufficient physical strength, cognitive abilities, and mobility compared with adults. Consequently, their capacity to recognize and respond to dangers is significantly diminished, which leaves them lacking in autonomous risk avoidance capabilities during emergencies such as fires or earthquakes [2]. Therefore, the design characteristics of children's spaces require special attention in many aspects, especially in children's gathering places with relatively single user types such as kindergarten buildings [4]. Further research has confirmed that optimizing the safety evacuation plans at the forefront of architectural design is a key pathway to achieving the best cost–benefit ratio. The decisions made by designers at this stage have a decisive impact on the safety and economy of the final built environment [5,6]. For example, the elements of classroom space layout can significantly improve evacuation efficiency: refining the exit design can markedly reduce evacuation times [7,8], while adjusting the layout of tables and chairs can improve the evacuation efficiency of evacuation personnel [9–11].

Although changing classroom indoor layouts can significantly improve evacuation efficiency, existing research has mostly focused on how children can escape the classroom and pursue maximum local efficiency. The research results are mostly scattered studies on the "components" of evacuation, and have not systematically analyzed activity units as a whole. Therefore, how to optimize the spatial configuration and furniture layout of activity units to improve the evacuation efficiency of kindergartens has become a key issue that urgently needs to be addressed.

1.2. Related Research

Building evacuation is a complex dynamic system that encompasses human behavior and the physical environment. In this system, apart from standardization and guidance behavior [12], performance-based architectural design is also an important method to improve the overall evacuation efficiency and safety standards [13].

In evacuation research, computer simulation has become a vital tool for predicting personnel behavior and optimizing evacuation design. Common evacuation models include the lattice gas model [14,15], agent-based model [16,17], cellular automaton model [18,19], and social force model [20]. Among these models, the social force models can effectively reflect behavioral characteristics during evacuation, which plays a key role in simulating evacuation phenomena. Among the simulation software based on the social force model, MassMotion (version 11.0) is a tool specifically designed for large-scale pedestrian simulation and crowd analysis [21]. This software can predict interactions between pedestrians and the surrounding built environment [22], optimize the space utilization efficiency [23], and assist in adjusting layout design [24,25]. For example, Li et al. [26] used MassMotion software to simulate the impact of different exits on evacuation. The study found that, under the condition of a higher expected speed of pedestrians, convex exits are more efficient and safer than flat exits in terms of evacuation time and alleviating pedestrian congestion. Therefore, convex exits are more suitable for crowd evacuation during emergencies. The verification results of researchers such as Marzouk [27] and Cuesta [24] further proved the accuracy of the prediction of this platform in school evacuation scenarios.

In the evacuation design of educational buildings, the position of classroom exits [6,28,29] and the layout of desks and chairs fundamentally determine safety by directly influencing occupants' behavioral choices and paths [19,29,30]. Therefore, optimizing the interior layouts of classrooms is the fundamental prerequisite and core task to ensure efficient and unimpeded evacuation processes. For example, Liu et al. [31] highlighted in classroom evacuation, students may lose their previously constrained escape ability, and, as the population density in the classroom increases, the evacuation process will

become more difficult. Research indicates that optimizing the exit design of classrooms can substantially reduce evacuation times [29,32]. Zhao et al. [33] show that classrooms with two exits can effectively reduce the evacuation time of students. Jian et al. [34] investigated single-sided layouts with two and three exits in classrooms. In the field of research on classroom desk and chair layout, the existing literature mostly focuses on the effect of traditional row-and-column matrix arrangements [19,29,35] on evacuation efficiency, particularly crowd dynamics within a unidirectional spatial configuration oriented toward the podium. For example, Song et al. [29] evaluated 10 effective classroom layouts and proposed that widening the passageway between the classroom and walls significantly enhances evacuation efficiency.

However, research on the evacuation issues of activity units in kindergartens is still insufficient. These activity units in kindergartens are the core spaces for preschool children to engage in teaching, play, and interact, with their exit design, spatial configuration and functional layouts directly impacting evacuation efficiency and safety. This research deficiency contrasts sharply with the unique spatial functions of kindergartens and the behavioral and cognitive characteristics of children. In recent years, some studies have begun to focus on the impact of children's behavior and the spatial design of kindergartens on evacuation efficiency, such as the number of exits and the layout form of classrooms in kindergarten, or they focus on macro fire protection regulations or children's psychological characteristics, etc., and seldom start from the coupling relationship between the space organization of building and internal layout, conducting refined and systematic evacuation simulation research for the activity units in kindergartens. Therefore, our study, based on the MassMotion simulation software (version 11.0), starts from how children escape from buildings and focuses on the specific impact of the spatial combination patterns of activity rooms and bedrooms, as well as the layout of furniture such as desks, chairs, and beds, on the evacuation efficiency. The characteristics of personnel flow and congestion under different spatial combination forms were systematically analyzed, and the most efficient spatial combination strategy and indoor layout form were clarified, providing a spatial supplement for the research on the evacuation of existing kindergarten buildings. Through simulation analysis of the coupling effect of the above two factors, a series of detailed design optimization guidelines were obtained, enabling the design of activity units in kindergartens to more economically and effectively enhance the safety evacuation capacity of buildings from the source and reduce the risk of casualties in emergency situations.

1.3. Research Questions and Hypotheses

Based on the above research gaps, this study aims to deeply explore how the coupling relationship between spatial organization and furniture layout in kindergarten activity units affects evacuation efficiency. Specifically, this study proposes the following core research questions and hypotheses:

How do different spatial combination patterns of activity rooms and dormitories in kindergartens affect the overall efficiency of children's evacuation process?

Based on the above research questions, we make the following hypotheses:

1. In the form of combining the activity room and the dormitory, placing the exit of the activity room at the far end and the exit of the dormitory at the near end can effectively guide and divert traffic, thereby significantly improving the overall evacuation efficiency under this mode and reducing corridor congestion caused by the concentration of exits.
2. In the form of separating the activity room from the dormitory, setting up an independent and direct exit for the activity room and optimizing the position of the connection exit between it and the dormitory can build a three-dimensional and clear evacuation

path network, thereby maximizing the safety potential of this mode and achieving systematic optimization of evacuation efficiency.

Under the above-mentioned different spatial combinations, how can the layout of furniture further adjust the evacuation efficiency?

Based on the above research questions, we make the following hypotheses:

1. In the activity room area, setting the layout of tables and chairs parallel to the main exit wall can create a smoother flow direction compared to a vertical layout to the wall, thereby significantly improving the evacuation efficiency of this area.
2. In the dormitory area, the use of retractable beds to clear the passageways in emergencies will have a more significant improvement effect on evacuation efficiency.

1.4. Objectives and Contributions

This study, which is based on the MassMotion model, aims to explore the impact of the exit location and indoor layout of kindergarten activity units on evacuation efficiency in emergency situations. On the basis of the research results, suggestions for the optimal design of kindergarten activity units are proposed. To achieve this goal, the research proceeds through the following steps:

1. Basic data acquisition: Through surveys of 42 kindergartens, common layouts for activity rooms and dormitory layouts within activity units are summarized, along with exit locations, distribution patterns of desks, chairs, and beds, and foundational data concerning evacuation procedures. This collection provides data support for the subsequent model construction and analysis.
2. Model construction: Based on the collected data, an evacuation simulation model based on MassMotion is established. The model incorporates children's behavioral characteristics and individual evacuation parameters throughout its development to realistically replicate emergency evacuation scenarios.
3. Evacuation scenario design and simulation: Based on the current design standards in China and the actual layout of activity units in kindergartens, multiple evacuation scenarios are designed for the layout forms of activity rooms and dormitories, the positions of the exits of activity units, the desks and chairs in activity rooms, and the beds in dormitories. Through simulation methods, the evacuation efficiency data of different schemes are obtained to provide quantitative support for the research.
4. Design optimization suggestions: Based on the simulation results, optimization suggestions for the layout of activity unit exits, tables and chairs, and beds are proposed to further enhance evacuation efficiency and ensure safety.

The findings of this research not only provide a theoretical basis for the layout design of activity units in kindergartens but also offer a scientific reference for future educational building design and the formulation of relevant standards. Furthermore, through this research, more scholars, social figures, developers, and other social groups are encouraged to pay attention to the issue of children's evacuation. Addressing this concern enhances children's survival capabilities in emergency situations and contributes to ensuring children's safety and well-being.

2. Model Research Foundation and Method Design

2.1. Research Group

Kindergartens are one of the places where children aged 3 to 6 receive preschool education. These facilities provide comprehensive education and care for children to promote their overall and healthy development. In China, kindergarten is typically a three-year program [36,37]. The program is divided into junior, middle, and senior classes, with each

year group corresponding to distinct learning content and educational objectives. According to China's Code for *Design of Buildings for Nurseries and Kindergartens* (JGJ39-2024) [38], kindergarten buildings should generally not exceed three stories to ensure safety and accessibility and facilitate evacuation. According to the standards, the floors where children are located have been set. The first floor of the building has small classes, with 25 students in each class. The second floor has medium classes, with 30 students in each class. The third floor has large classes, with 35 students in each class. Meanwhile, the activity units in kindergartens are the main places for children's life and study, and daily activities are usually completed within these units [39]; in terms of the planar form, kindergarten buildings mostly adopt the linear layout form because it can effectively optimize the ventilation and lighting performance of the rooms [36,40]. Therefore, this study conducts analysis based on a linear layout. This research mainly focuses on the primary usage space of children, that is, the activity units in kindergartens. Through the survey of a large number of activity units in kindergartens across China, the general forms of various evacuation elements in kindergarten activity units are investigated and summarized (Table A1). The findings lay the foundation for the construction of the basic model of activity units in the later stage.

2.2. Methods

The simulation process of this study mainly includes the following four stages. 1. Based on the current Chinese norms, the typical floor plan layout of kindergarten buildings and the floor plan design of different research schemes are constructed. 2. Based on the design plan, a 3D architectural model is created in SketchUp, which is then exported as an IFC format file. 3. The abovementioned IFC file is imported into the MassMotion software platform to configure the parameters of the emergency evacuation scene and define the personnel behavior model. 4. Simulation is conducted to summarize the evacuation result data and analyze the causes. The specific simulation flowchart is shown in Figure 1.

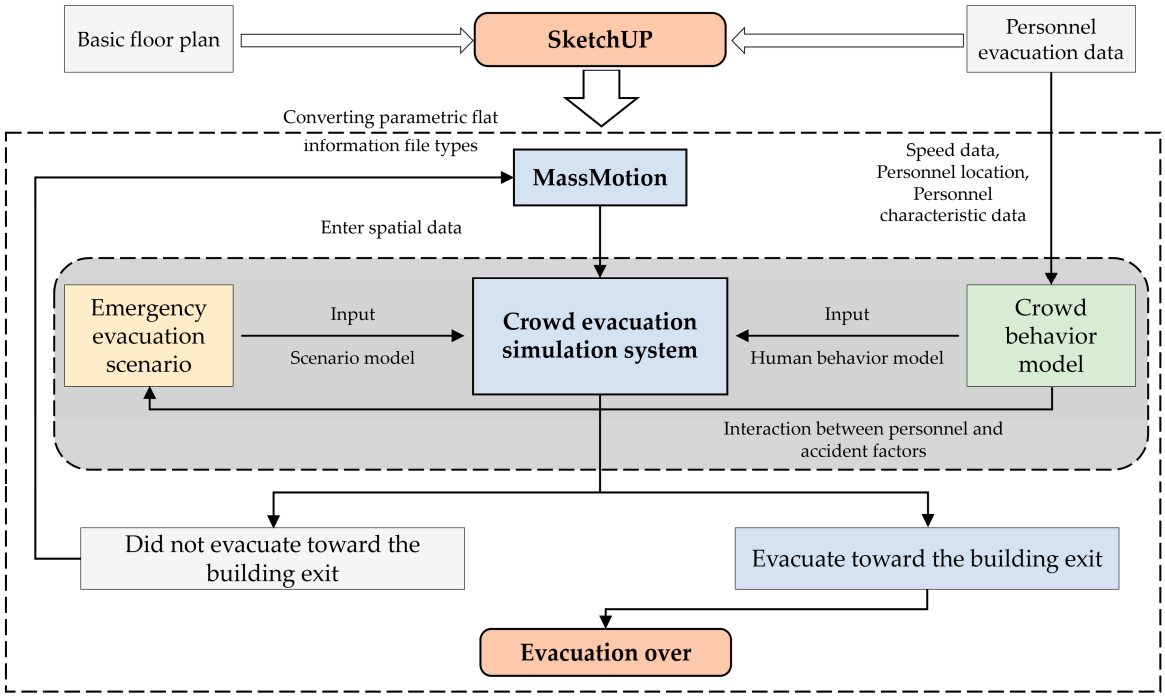


Figure 1. Experimental flowchart.

2.3. MassMotion Modeling Principle

The agents in MassMotion represent pedestrians in the real world. They have certain behavioral decision-making capability and can move based on the environment, targets, and the influence of other pedestrians. Meanwhile, we simulate different types of crowd behaviors by configuring agent attributes, such as speed, height, weight, target position, behavioral preferences and so on. Meanwhile, existing research indicates that when the number of runs reaches 25 to 30 times, the confidence intervals of key indicators tend to stabilize, and further increasing the number of runs has a very limited impact on the improvement of statistical significance [41–43]. Therefore, this study chose to run the simulation 30 times. To strictly verify the reliability of the results, we further conducted significance tests on all scenarios and confirmed that the differences were statistically significant ($p < 0.05$). In this study, the agent represents children in real life. In the social force model, children are subject to the combined action of multiple forces, which consist of three fundamental forces: the child's self-propulsion force, the interaction force among children, and the interaction force and interference force between children and obstacles. This model is expressed as follows:

$$m_i \frac{dv_i}{dt} = m_i \frac{v_i^o(t)e_i^o(t) - v_i(t)}{\tau_i} + \sum_{j(\neq i)} f_{ij} + \sum_w f_{iw} \quad (1)$$

In the formula, m_i is the mass of the child, and i is the velocity vector of the child; $v_i^o(t)$ and $v_i(t)$ are, respectively, the expected and actual speeds of the child; $e_i^o(t)$ is the expected direction of motion; τ_i is the reaction time; f_{iw} represents the force between child i and the obstacle w, and f_{ij} indicates the interaction force between child i and child j.

The expression formula of the interaction force between children is:

$$f_{ij} = A_i exp\left[\left(r_{ij} - d_{ij}\right)/B_i\right] n_{ij} + kg\left(r_{ij} - d_{ij}\right) n_{ij} + kg\left(r_{ij} - d_{ij}\right) \Delta v_{ji}^t t_{ij} \quad (2)$$

In the formula, $A_i exp\left[r_{ij} - d_{ij}/B_i\right]$ is the psychological repulsive force among children; $kg\left(r_{ij} - d_{ij}\right)$ is the physical repulsive force between children; $kg\left(r_{ij} - d_{ij}\right)\Delta v_{ji}^t t_{ij}$ is the frictional force between children. The social force model takes into account the interactions between people and between people and the external environment. On this basis, individuals can independently maintain an appropriate distance from other individuals and obstacles [44]. It describes the psychological tendency of two agents by a repulsive interaction, where A_i and B_i are all constants, and κ and K represent the sliding friction coefficient and body compression coefficient.

The formula for expressing the force exerted by obstacles on children is:

$$f_{ij} = A_i exp[(r_i - d_{iw})/B_i] n_{iw} + kg(r_i - d_{iw}) n_{iw} + kg(r_i - d_{iw})(v_i \cdot t_{iw}) t_{iw} \quad (3)$$

In the formula, d_{iw} represents the distance between child i and the wall w; n_{iw} and t_{iw}, respectively, represent the normal and tangential directions of the child and the wall.

2.4. Evacuation Personnel Parameters

The MassMotion simulation software does not incorporate gender parameters, and physical characteristics among children aged 3 to 6 years do not exhibit significant variation. Thus, this study selected the movement speed, height, and body thickness of the agent as key variables to distinguish children across different age groups. Based on the Chinese standard "*GB/T 26158-2010 Body Dimensions of Minors in China*" [45] and the measured body size data of preschool children conducted by the research team [46,47], the body dimensions of children were compiled (Table 1).

Table 1. Simulation parameters of agent body dimensions.

Age Group	Height (cm)	Shoulder Width (mm)	Body Thickness (mm)
Primary class	104	228	170
Middle class	110	242	182
Large class	116	254	192

Agents within the MassMotion simulation software can dynamically adjust evacuation speeds according to traffic conditions. Thus, this study used existing experimental data of evacuation of preschool children in China [48], along with the simulation data collected by the research team through experiments. To meet the requirements of the MassMotion platform [47], the speed parameters of the agent in the simulation were set, as shown in Table 2. The agent speed setting diagram of the Massmotion software interface is in the Figure 2.

Table 2. Simulation speed parameters of Agent.

Age Group	Maximum Speed (m/s)	Minimum Speed (m/s)	Average Speed (m/s)	Standard Deviation (m/s)
Primary class	0.83	0.41	0.65	0.150
Middle class	1.13	0.54	0.81	0.154
Large class	1.51	0.64	1.02	0.149

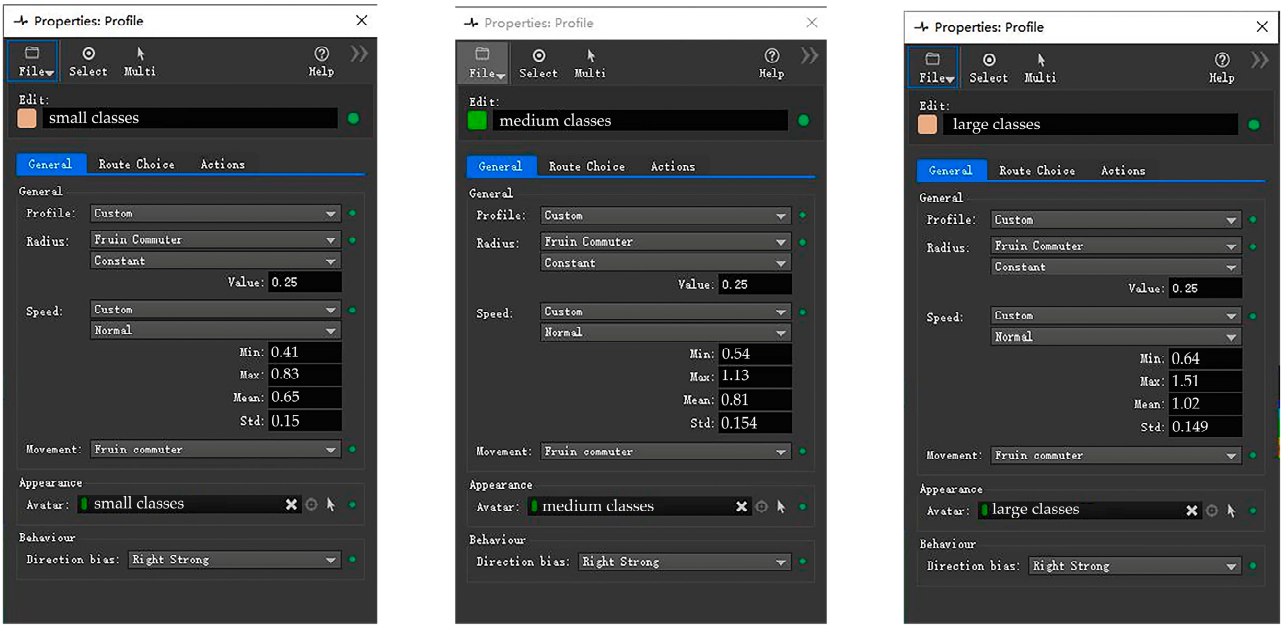


Figure 2. The agent speed setting diagram of the Massmotion software interface.

2.5. Construction of Basic Planar Models

According to the requirements for living quarters in kindergartens stipulated in the Code for *Design of Buildings for Nurseries and Kindergartens* (JGJ39-2024) [38], if activity rooms and dormitories are shared, then the minimum usable area of each room should not be less than 120 m^2. If the activity room and the dormitory are separated, then the minimum usable area of the activity unit room should comply with the requirements shown in Table 3.

Table 3. Minimum usable area for kindergarten activity units.

Room Name		Minimum Usable Floor Area of a Room
Activity room		70 m^2
Dormitory		60 m^2
Bathroom	Toilet	12 m^2
	Washroom	8 m^2
Walk-in wardrobe		9 m^2

This study constructed a basic floor plan model (Figure 3) based on the functional characteristics of kindergartens. The relevant dimensions and areas of this model comply with the requirements of China's Code for *Design of Buildings for Nurseries and Kindergartens* (JGJ39-2024) [38] and the Code for *Fire Protection Design of Buildings* (GB50016-2014, 2018 Edition) [49]. The specific data are shown in Table 4.

Table 4. Design Specifications for Activity Unit Layout.

Requirements in Building Regulations		The Settings Within the Model
Code for *Design of Buildings for Nurseries and Kindergartens* (JGJ39-2024) Code for *Fire Protection Design of Buildings* (GB50016-2014, 2018 Edition)		
Active area per unit	The activity room should be filled to 70 m^2, the dormitory to 60 m^2, and the bathroom to 12 m^2	The activity room is 70 m^2, the dormitory is 60 m^2, and the bathroom is 12 m^2
Depth of the activity room	The depth of the activity room should be less than 6.6 m	6.6 m
Stair tread height and width	The height of the stair treads should be 0.13 m and the width should be 0.26 m	0.13 m × 0.26 m
Distance between activity unit exit and corridor	The maximum distance between the exit of the activity unit and the corridor should be less than 25 m, and it should be less than 20 m for bag-type corridors	<25 m
Door width	Rooms for children such as activity rooms and dormitories should be equipped with double swing doors, and the clear width of the doors should not be less than 1.20 m	1.2 m

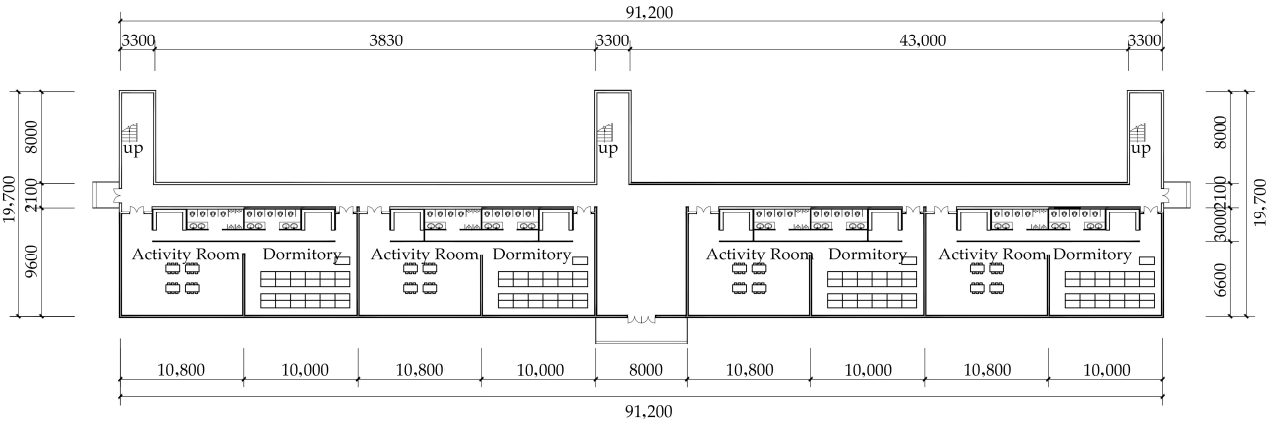


Figure 3. Basic planar model.

3. Results

3.1. Case Research

This study investigated 42 kindergartens meeting current Chinese architectural design standards for kindergartens as samples. The samples covered 13 provinces, municipalities, and autonomous regions including Beijing City, Anhui Province, Henan Province, Shandong Province, and the Inner Mongolia Autonomous Region, as detailed in Appendix A. Based on the selected samples, this study summarized the specific practical manifestations of several key factors and took them as the basis and foundation for the construction of evacuation scenarios. After analyzing the research samples, the detailed results of each part are summarized as follows:

Activity Unit Format

The research results indicate that the activity units in kindergartens are usually composed of activity rooms and dormitories. Two main combination forms are observed: the first type is the shared use of activity rooms and dormitories, and the second type is the separation of activity rooms and dormitories, as detailed in Table 5. Statistical analysis of the survey data on the combination form of activity units indicates that the form of combined activity rooms and dormitories is significantly more common, with a higher proportion than the form of separated activity rooms and dormitories, as shown in Table 6.

Table 5. Survey results on activity room and dormitory layout.

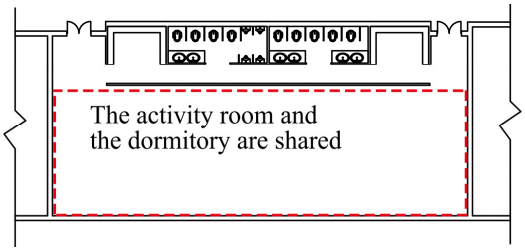
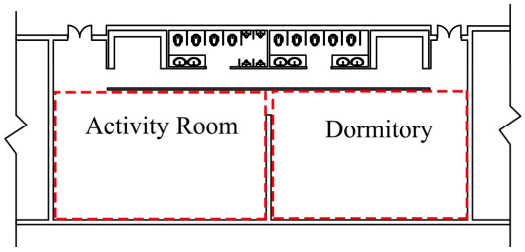
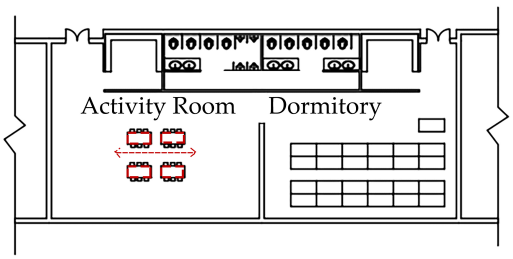
	Positional Relationship	Schematics	Characteristics
Activity Unit Layout Formats	Activity room and dormitory combined		The activity room and dormitory are combined, with no barriers between the spaces.
	Activity room and dormitory separated.		The activity room and dormitory are separated by a partition wall in the middle of the space.
Layout of activity unit furniture and dormitory beds	Horizontal arrangement of tables and chairs		Activity room furniture arrangement parallel to the exit wall

Table 5. *Cont.*

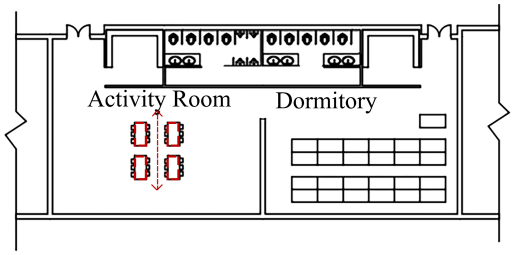
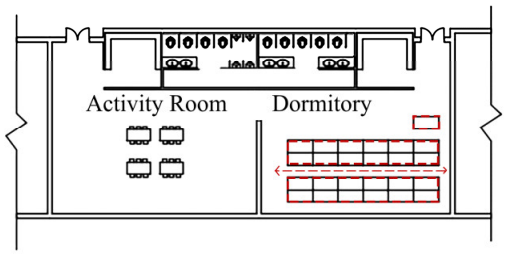
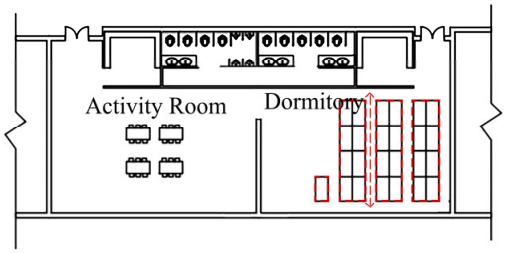
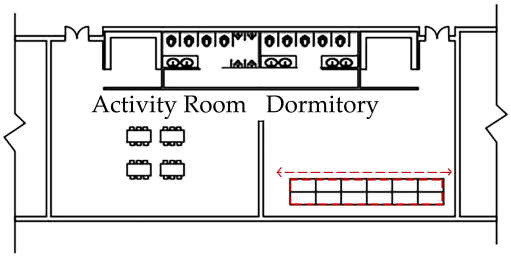
	Positional Relationship	Schematics	Characteristics
Layout of activity unit furniture and dormitory beds	Longitudinal arrangement of tables and chairs		Activity Room Furniture Arrangement Perpendicular to Exit Wall
	Horizontal bed arrangement		Bed arrangement in dormitory rooms parallel to the exit wall
	Longitudinal arrangement of beds		Layout of vertical exit walls for dormitory beds
	Bed with storage layout		Bed storage arrangements in dormitories should be positioned away from exits

Table 6. Survey results on activity rooms and dormitory formats.

Activity Rooms and Dormitory Formats	Total		Effective Quantity	
	Quantity (Number)	Proportion (%)	Quantity (Number)	Proportion (%)
Combined activity room and dormitory (1)	317	65.63	32	64.00
Separated activity room and dormitory (2)	166	34.37	18	36.00
Total	483	100.00	50	100.00

Note: (1): The activity room and the dormitory space are combined for use; (2): The activity room and the dormitory space are separated for use.

3.2. Construction of Evacuation Scenarios

In MassMotion, it is necessary to construct simulated architectural Spaces, which are composed of the ground, connections, stairs, ramps, escalators, entrances and exits, obstacles, service facilities, and intelligent agents (Figure 4). Based on the basic plane established in Chapter 2.5, this study constructed a physical evacuation scene in SketchUp software (version 2019) and exported it as an IFC format file. Import the above-mentioned

IFC file into the MassMotion software platform, configure the parameters of the emergency evacuation scenario, and define the personnel behavior model. Click "Start Simulation". If the agent finally enters the set exit, it is considered successful. If the agent ultimately fails to enter the set exit, it is considered a failure and needs to be re-simulated. As shown in Figure 5, the planar layout of the active unit has been truly restored, with the dimensions and positioning of each functional area strictly adhering to the actual design parameters. This adherence ensures the reliability and operational feasibility of the simulation results.

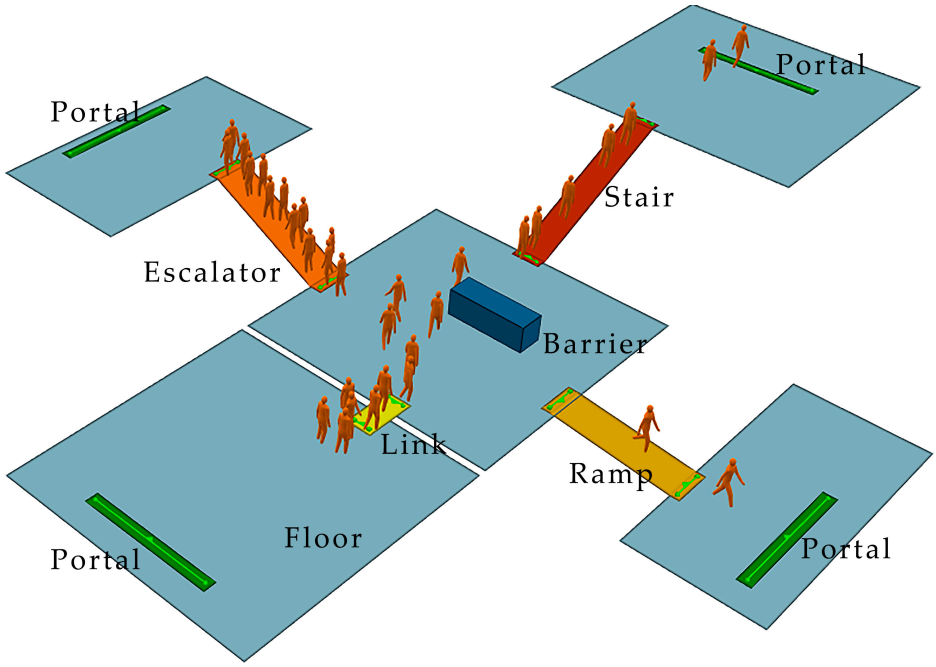


Figure 4. Evacuation model function diagram.

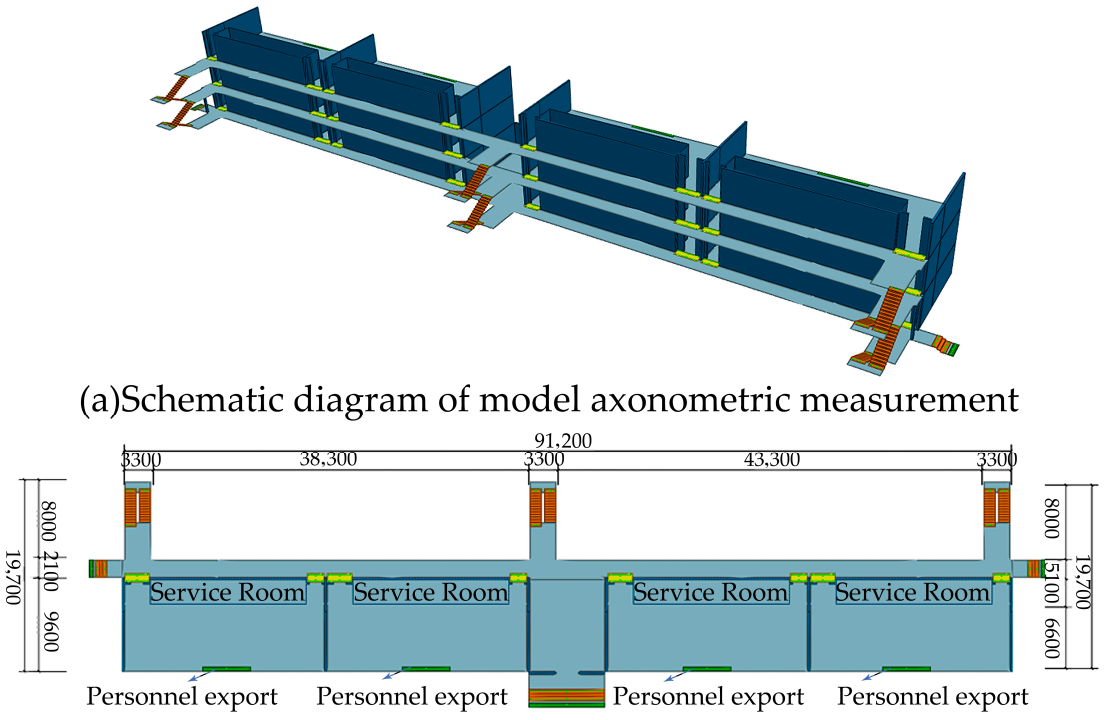


Figure 5. Schematic of the basic plane MassMotion model.

As shown in Figure 6, in accordance with the design standards for Chinese kindergartens, we set the exits of the activity units on the long side walls and selected the exit points at the ends and the middle of the activity rooms and dormitories respectively. At the same time, the connection exits between the activity room and the dormitory are also selected at the end and middle positions in accordance with the same principle. The exits of each activity unit are centrally arranged on one side of the unit and directly face the corridor. By systematically arranging and combining the above-mentioned exit positions, the research plan of this paper is finally formed. This layout not only meets the convenience requirements for daily circulation patterns in the kindergarten but also provides foundational conditions for rapid evacuation during emergencies. However, the single-sided exit design may trigger a potential bottleneck effect during the evacuation of high-density crowds. Consequently, this study specifically conducted multi-scenario simulation tests to validate its feasibility. Notably, when constructing the simulation model, the study thoroughly considered the actual usage patterns of service rooms, such as the open status of secondary functional spaces including storage rooms and toilets, and their impact on primary evacuation routes. Based on these actual usage scenarios, evacuation scenarios were established.

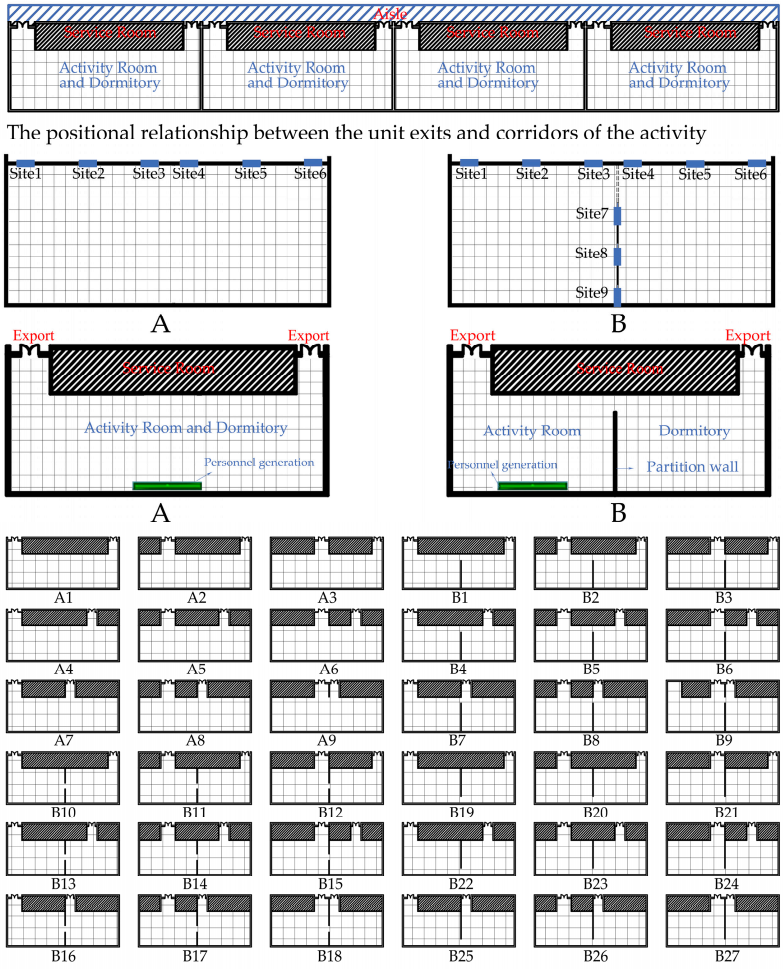


Figure 6. Schematic of export plan.

3.3. Evacuation Result

3.3.1. Combined Activity Room and Dormitory

We conducted simulation tests on the 36 schemes mentioned above, with each group of schemes being simulated 30 times. The data statistics in Figure 7 show that the evacuation time range for the combined layout of activity rooms and dormitories is from 195.04 s to 226.36 s. Plan A6 shows significant differences from other layouts in terms of average evacuation time. Compared with the time in the worst-case evacuation scenario, the average evacuation time of plan A6 is reduced by 13.84%. The data statistics in Figure 8 show that the average density of schemes A2, A6, and A9 is relatively low, while that of the other schemes is higher than those of the three schemes.

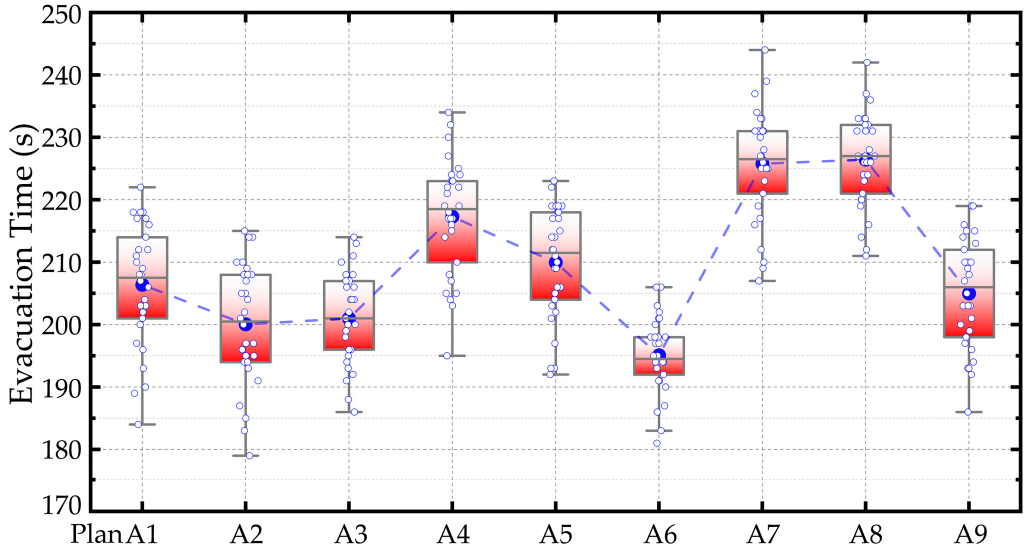


Figure 7. Escape route diagram for building evacuation under the combined layout of activity room and dormitory unit exits.

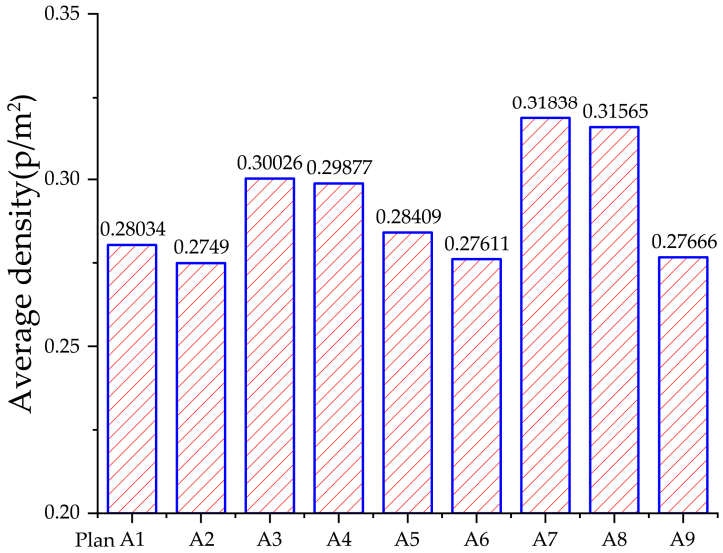


Figure 8. Column chart of average density under the combined layout of activity room and dormitory unit exits.

Table 7 shows that, under the combined layout of activity room and dormitory exits, when the exit position of the dormitory within the activity unit remains unchanged, reducing the distance between the activity room and the dormitory exit (schemes A1–3, A4–6,

and A7–9) results in a significant difference in overall average evacuation time ($p < 0.05$). Notably, a decreasing trend is observed in the overall average evacuation time.

Table 7. Statistically examines the data on the impact of the location of the dormitory exit shared by the activity room and the dormitory on the distance between the activity room and the dormitory on the evacuation time.

Test Name	Plan	N	Mean Value	Standard Deviation	The Standard Error of the Mean	*p*
T-test	A1	30	206.40	9.65	1.76	$p < 0.05$
	A2	30	200.07	9.53	1.74	
	A1	30	206.40	9.65	1.76	$p < 0.05$
	A3	30	201.00	7.32	1.34	
	A4	30	217.30	9.30	1.70	$p < 0.05$
	A5	30	209.97	8.88	1.62	
	A4	30	217.30	9.30	1.70	$p < 0.05$
	A6	30	195.10	6.04	1.10	
	A7	30	225.80	8.89	1.62	$p > 0.05$
	A8	30	226.43	7.49	1.37	
	A7	30	225.80	6.04	1.10	$p < 0.05$
	A9	30	205.00	8.82	1.61	

Table 8 shows that, under the combined layout of activity room and bedroom exits, when the position of the activity room exit within the activity unit remains unchanged and the distance between the activity room and bedroom exits is reduced (schemes A1, 4, 7; A2, 5, 8; A3, 6, 9), the overall average evacuation time exhibits significant differences ($p < 0.05$). Notably, when the exit of the activity room is set at position 3, the difference in the average evacuation time is not significant ($p > 0.05$). Specifically, the average evacuation time first decreases and then increases, while the average evacuation time of other schemes shows an increasing trend.

Table 8. Presents statistical test data demonstrating the impact of activity room exit positioning within combined activity and sleeping quarters on evacuation times, which are obtained based on the distance between activity and sleeping quarters.

Test Name	Plan	N	Mean Value	Standard Deviation	The Standard Error of the Mean	*p*
T-test	A1	30	206.40	9.65	1.76	$p < 0.05$
	A4	30	217.3	9.30	1.70	
	A1	30	206.40	9.65	1.76	$p < 0.05$
	A7	30	225.80	8.89	1.62	
	A2	30	200.07	9.53	1.74	$p < 0.05$
	A5	30	209.97	8.88	1.62	
	A2	30	200.07	9.53	1.74	$p < 0.05$
	A8	30	226.43	7.49	1.37	
	A3	30	201.00	7.32	1.34	$p < 0.05$
	A6	30	195.10	6.04	1.10	
	A3	30	201.00	7.32	1.34	$p > 0.05$
	A9	30	205.00	8.82	1.61	

3.3.2. Separated Activity Room and Dormitory

The data statistics in Figure 9 show that the evacuation time range for the separated layout of the activity room and dormitory is from 194.96 s to 224.43 s. Schemes B1, B4, B7, B10, B13, B16, B19, B22, and B26 have significant differences from other layouts in terms of average evacuation time. Compared with the worst evacuation time in the separated layout of activity rooms and dormitories, the average evacuation times of the abovementioned schemes are reduced by 12.45%, 13.05%, 13.03%, 12.81%, 12.64%, 10.93%, 13.13%, 12.25%, and 12.57%.

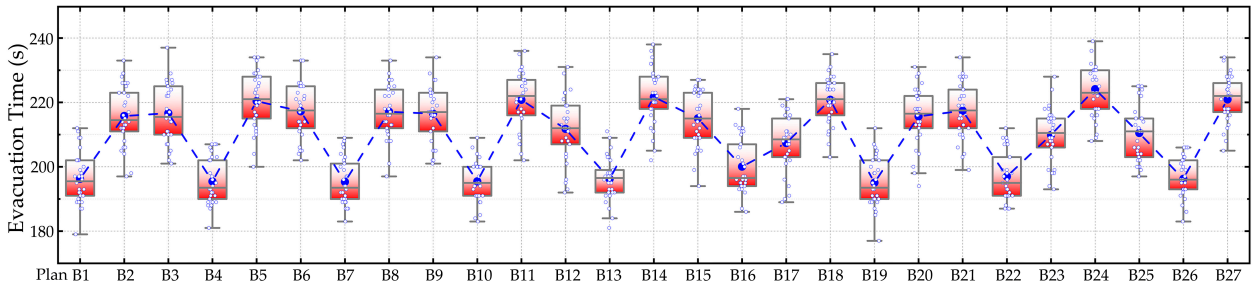


Figure 9. Escape data box layout for building evacuation under the separated layout of activity room and dormitory unit exits.

Figure 9 shows that, under the layout where the activity room and the dormitory are separated and when the exit of the activity room is set at position 1, the overall average evacuation time is relatively short. Table 9 shows that, when the exit positions of the dormitories in the activity unit remain unchanged, the distance between the activity room and the dormitory exit is reduced. This reduction results in longer average evacuation times for activity room exits positioned at locations 2 and 3 compared with location 1 ($p < 0.05$), except when the sleeping quarter exit is at location 4 and the activity room exit is at location 9.

Table 9. Statistical test data on the effect of activity room exit positions on evacuation times when activity rooms and bedrooms are separated.

Test Name	Plan	N	Mean Value	Standard Deviation	The Standard Error of the Mean	*p*
T-test	B1	30	196.23	7.88	1.44	$p < 0.05$
	B2	30	215.77	9.20	1.68	
	B1	30	196.23	7.88	1.44	$p < 0.05$
	B3	30	216.67	9.11	1.66	
	B4	30	195.43	7.06	1.29	$p < 0.05$
	B5	30	220.40	8.79	1.61	
	B4	30	195.43	7.06	1.29	$p < 0.05$
	B6	30	217.23	8.32	1.52	
	B7	30	195.30	7.12	1.30	$p < 0.05$
	B8	30	217.10	8.37	1.53	
	B7	30	195.30	7.12	1.30	$p < 0.05$
	B9	30	216.50	8.69	1.59	
	B10	30	195.47	6.31	1.15	$p < 0.05$
	B11	30	220.80	9.00	1.64	
	B10	30	195.47	6.31	1.15	$p < 0.05$
	B12	30	211.77	1.15	1.85	
	B13	30	196.20	6.78	1.24	$p < 0.05$
	B14	30	221.70	8.79	1.61	
	B13	30	196.20	6.78	1.24	$p < 0.05$
	B15	30	215.03	8.81	1.61	
	B16	30	200.03	8.35	1.52	$p < 0.05$
	B17	30	207.37	8.96	1.64	
	B16	30	200.03	8.35	1.52	$p < 0.05$
	B18	30	220.80	7.42	1.35	
	B19	30	195.07	7.80	1.42	$p < 0.05$
	B20	30	215.67	9.08	1.66	
	B19	30	195.07	7.80	1.42	$p < 0.05$
	B21	30	217.40	8.70	1.59	
	B22	30	196.97	7.55	1.38	$p < 0.05$
	B23	30	209.87	8.49	1.55	
	B22	30	196.97	7.55	1.38	$p < 0.05$
	B24	30	224.10	9.57	1.74	

Evacuation Results at Different Exit Locations

Figure 10 shows that, when the exit of the activity room is set at position 1, the evacuation efficiency of separating the activity room from the dormitory is higher than that of sharing the activity room and the dormitory. When the exit of the activity room is set at position 2 and the exit between the activity room and the dormitory is set at position 9, the evacuation efficiency of the separated activity room and dormitory is higher than that of the combined activity room and dormitory. In other cases, the evacuation efficiency when the activity room and the dormitory are combined is higher than that when they are separated. When the activity room exit is positioned at location 3, the evacuation efficiency for separating the activity room and dormitory is markedly lower than that for combining them.

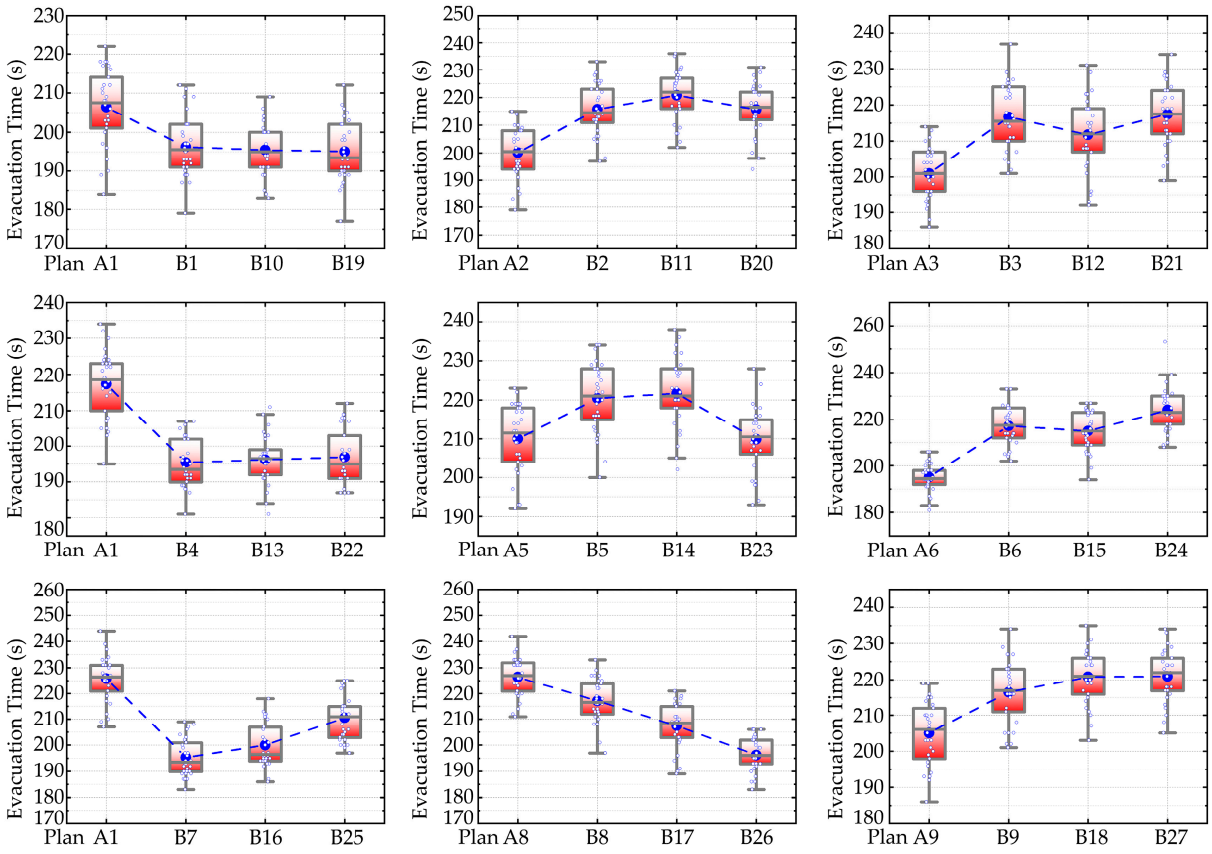


Figure 10. Comparison box diagram of evacuation time between the combined use of the activity room and the dormitory and the separation of the activity room and the dormitory from the building for evacuation.

3.3.3. Evacuation Result of the Layout of Tables and Chairs in the Activity Unit

This section presents two different table and chair layouts in the activity room and three bed layout schemes in the dormitory for modeling (non-storable and storable beds). The models employ identical parameters to those used in prior studies of washrooms and exits, with optimal layouts serving as baseline configurations. A total of 12 schemes are established, as shown in Figure 11.

We conducted simulation for the 12 schemes mentioned above, with each group of schemes being simulated 30 times. Figure 12 shows that the evacuation efficiency of the tables and chairs in the activity room, which are arranged parallel to the exit wall, is higher than that of those arranged perpendicular to the exit wall, and the difference is significant

($p < 0.05$). The parallel arrangement achieves a 4.56% improvement in evacuation efficiency (9.17 s) compared with the worst-case scenario of perpendicular arrangement.

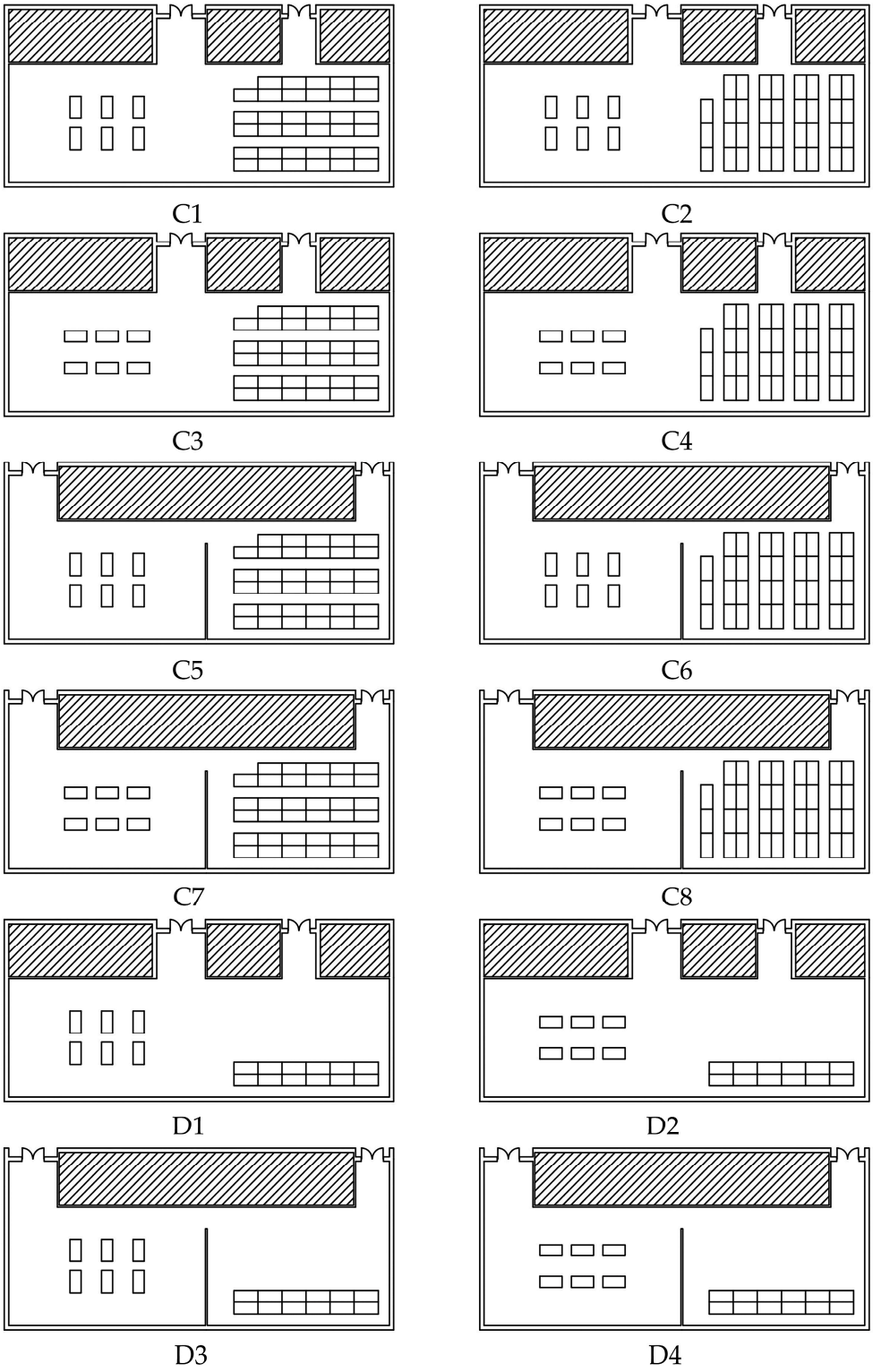


Figure 11. 12 possible evacuation scenarios for the layout of tables, chairs, and beds in the activity units.

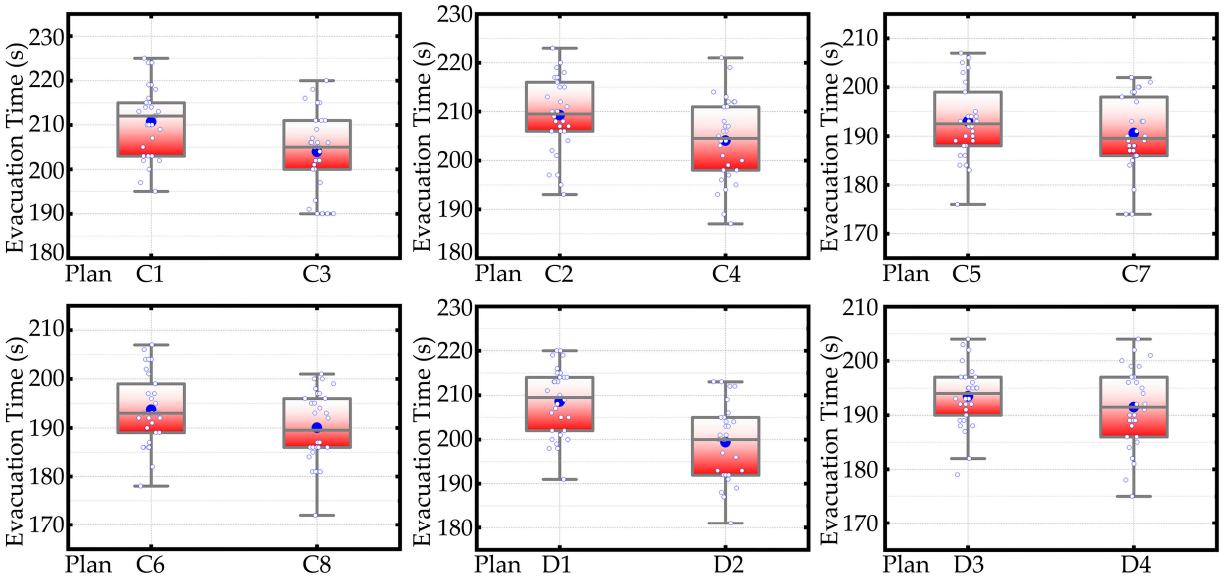


Figure 12. Box plot of evacuation times for parallel and perpendicular arrangements of furniture in activity rooms.

This study also compared the impact of dormitory bed layout on evacuation efficiency. Figure 13 shows that, when dormitories employ non-stowable beds, the average evacuation times for beds positioned vertically and parallel to the exit wall are comparable, with no significant difference in evacuation efficiency observed ($p > 0.05$).

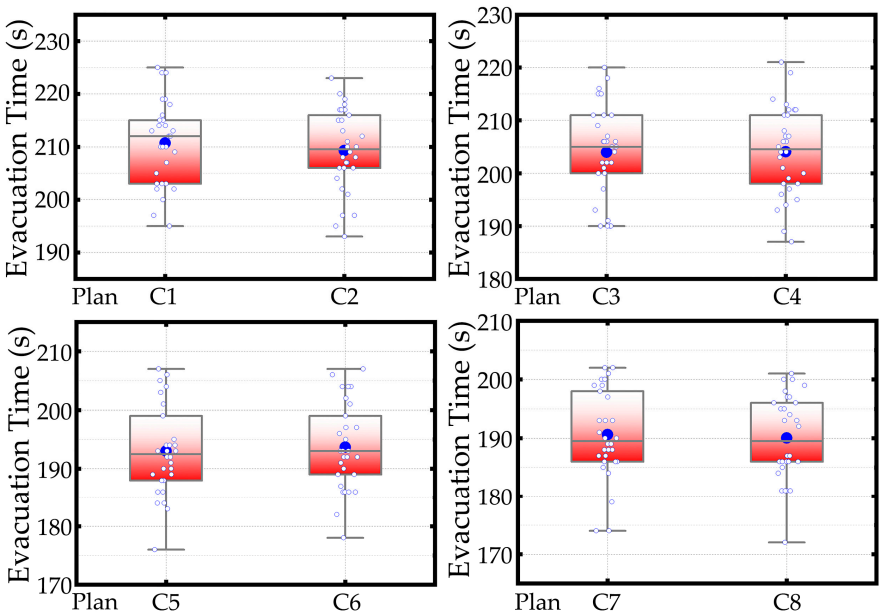


Figure 13. Evacuation data diagram for parallel and vertical arrangement of dormitory beds.

Figure 14 shows that, when storable beds are used in the dormitory, the evacuation efficiency of the combined layout of the activity room and the dormitory, which adopts the bed folding scheme, is relatively high ($p < 0.05$), and the evacuation efficiency is increased by 2.29% compared with that in the worst situation. When the activity room and the dormitory are arranged separately, the storable bedding exerts minimal influence on evacuation efficiency, with no significant difference observed ($p > 0.05$).

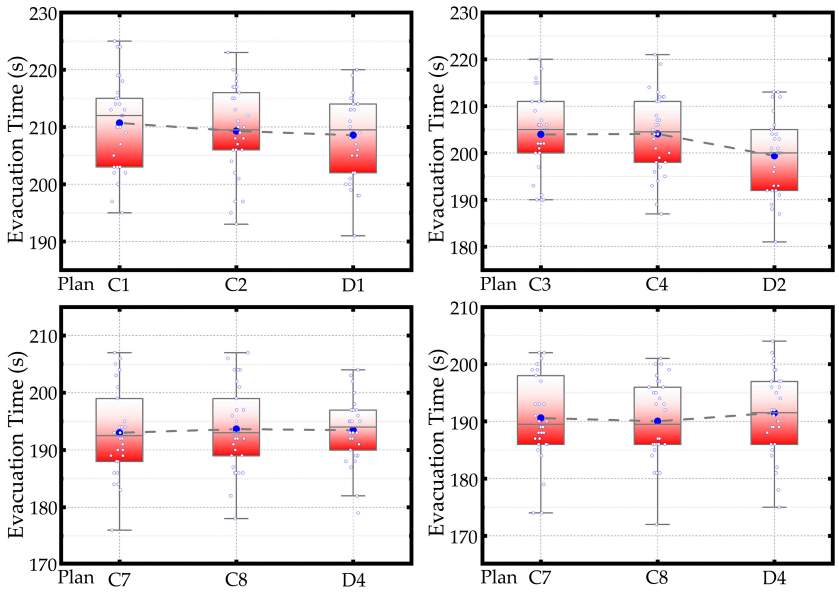


Figure 14. Comparison chart of evacuation times for non-storable and storable beds.

4. Discussion

This study developed an evacuation simulation model for activity units in kindergartens based on the distinctive behavioral characteristics of young children. Through the evacuation simulation of different activity unit layouts, the influence of factors such as the exit position of activity units and the layout of furniture on the evacuation efficiency of children's groups was comprehensively explored. As a result, a prediction model of the relationship among exit position, furniture layout, and evacuation time of children's groups was obtained.

4.1. Impact of Activity Unit Exits on Evacuation

4.1.1. Impact of Shared Exit Between Activity Room and Dormitory on Evacuation

Figure 15a,b show that, when the distance between the exit of the activity room and the dormitory reduces, the distance for evacuees to reach the exit of the activity room shortens. This shortened distance exacerbates the congestion at the exit of the activity room and reduces the efficiency of evacuees to escape the activity unit. However, reducing this distance helps alleviate the congestion at evacuation bottlenecks such as corridors and stairwell entrances, which enhances the overall evacuation efficiency (Figure 15).

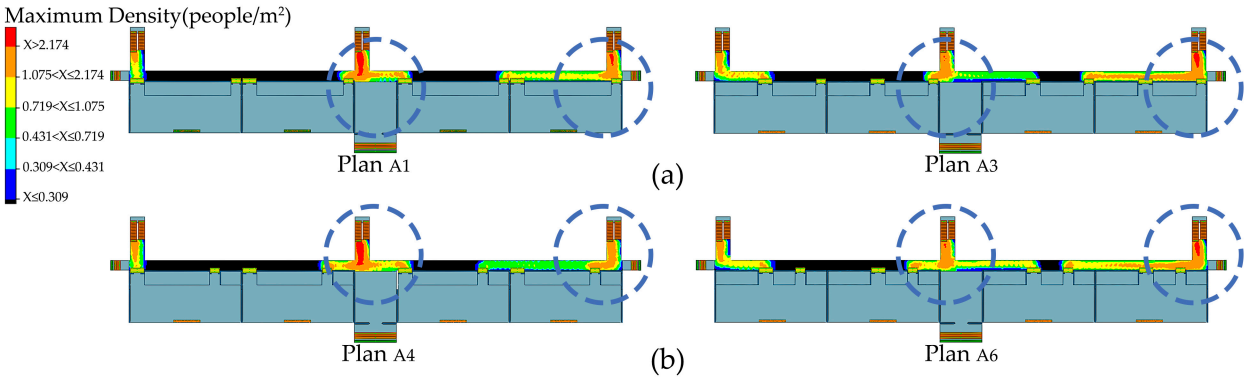


Figure 15. (**a**) Comparison of Maximum Pedestrian Density between Scheme 1 and Scheme 3; (**b**) Comparison of Maximum Pedestrian Density between Scheme 4 and Scheme 6.

Figure 16 shows that, when the dormitory exit is set at position 4, the shorter distance traveled by evacuees to reach the exit exacerbates congestion at the exit point, which reduces overall evacuation efficiency. By reducing the distance between the activity room and the dormitory exit, congestion at the exit can be decreased and the evacuation bottleneck at the activity unit exit can be alleviated [50]. Ultimately, the overall evacuation efficiency is improved.

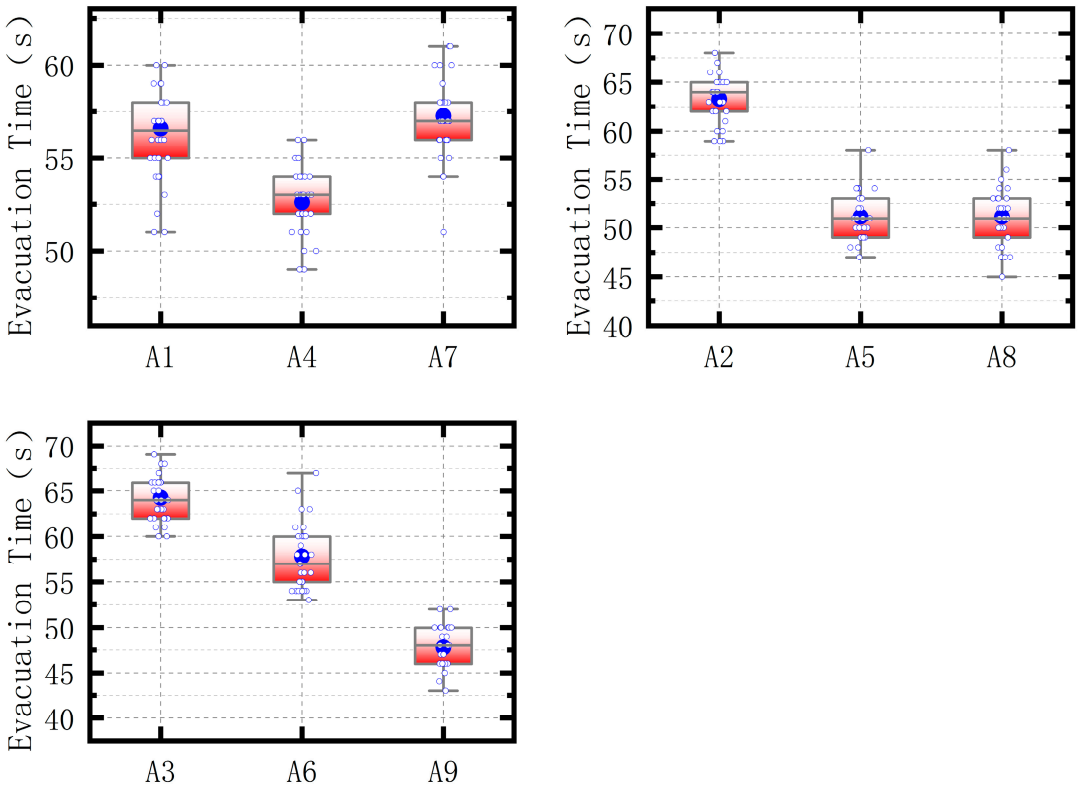


Figure 16. Comparison box plot for evacuation times of escape units under the combined layout of activity room and dormitory.

When evacuees move towards the exit position in the same direction, they will move in the same direction with a linear queue will be formed. Meanwhile, they cross the corridor width and overtake those in front of them. This phenomenon is called "overtaking behavior" [51,52]. This phenomenon can lead to the impact and squeezing between people at the exit, ultimately resulting in a decrease in evacuation efficiency [53]. Figure 17 shows that, when the position of the activity room exit remains unchanged and the dormitory exit is set at position 5, the distance for evacuees to reach the dormitory exit gradually decreases. This decreased distance leads to an intensification of congestion at the dormitory exit. When the dormitory exit is set at position 4, more evacuees choose either the activity room or the dormitory exit for evacuation. This choice intensifies overall congestion at the exits of the activity unit, which leads to a decrease in the overall evacuation efficiency.

When the exits of the activity units are set at positions 2 and 3, the distance between the dormitory and the exit of the activity room is shortened, which helps alleviate the congestion at the exit of the activity room and improves the efficiency of people escaping from the activity units (Figure 18). It also increases the congestion at the evacuation bottlenecks such as the corridor and staircase entrances. This situation results in a varying degree of overall deterioration in evacuation efficiency (Figure 19).

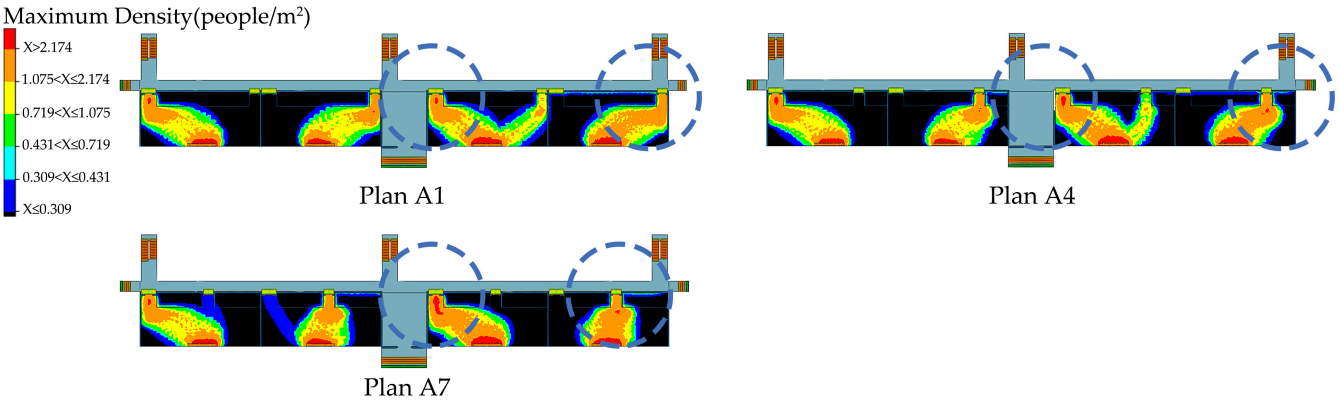


Figure 17. Comparison chart of the maximum evacuation density of activity units A1, A4, and A7.

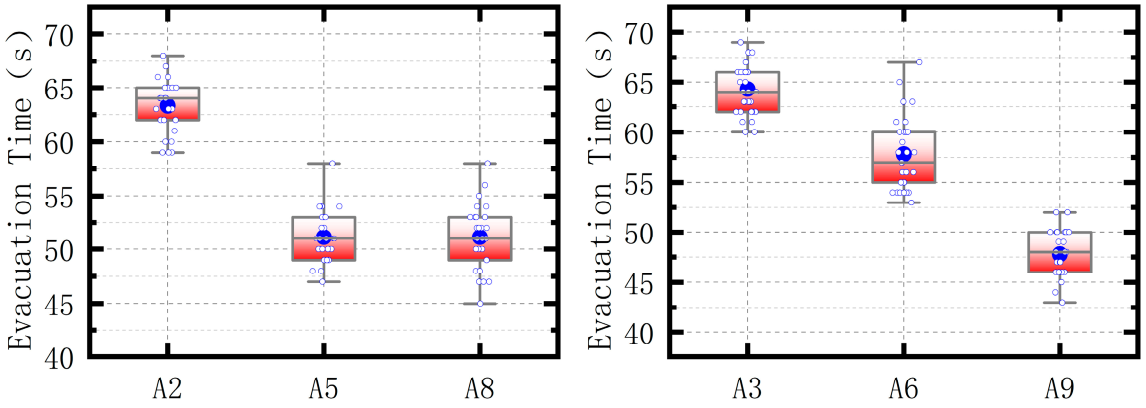


Figure 18. Box-and-whisker plot comparing evacuation time data for combined activity and sleeping quarters during escape drills.

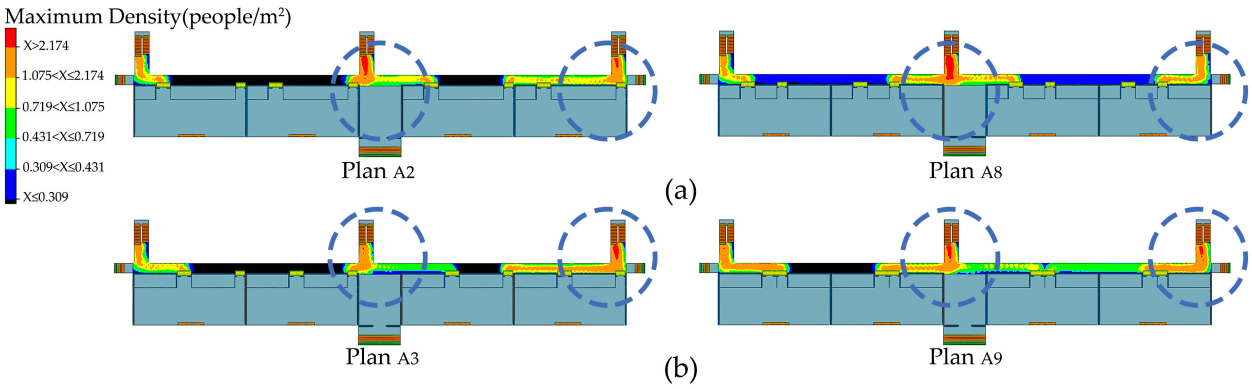


Figure 19. (**a**) Comparison of Maximum Pedestrian Density between Scheme 2 and Scheme 8; (**b**) Comparison of Maximum Pedestrian Density between Scheme 3 and Scheme 9.

Existing research often regards "room" as the core risk unit, focusing on reducing the time spent indoors and optimizing the efficiency of door passage [8,33,54], simply pursuing the rapid escape of evacuating personnel from the classroom. This reveals that the earlier the personnel leave the room, the safer the overall evacuation will be. It does not reveal the dynamic coupling relationship between the room and the corridor, staircase, and exit. However, our study, through the results of simulation, proves the irrationality of the assumption that the earlier people leave the room, the safer the overall evacuation will be, once again confirming the phenomenon that "fast is slow" [55].Oue study further indicates that the bottleneck effect at the corridors and stairwells in kindergartens is directly

related to the instantaneous peak flow of people induced at exits. This finding supports the proposition by Li et al. [56] that staggered evacuation enhances evacuation efficiency and reduces congestion [57]. In the future, Internet of Things sensors can be embedded in architectural design [58] to monitor pedestrian density in real time and adjust the exit guidance strategy [59].

The coupling effect of the combined organization model of activity rooms and dormitories and the exit positioning strategy is statistically significant. In combined activity room and dormitory arrangements, positioning activity unit exits centrally facilitates rapid evacuation from the activity unit [8]. However, it will cause congestion at the corridor and staircase entrance, which ultimately results in a decrease in the overall evacuation efficiency.

4.1.2. Impact of Separate Exits for Activity Rooms and Dormitories on Evacuation

When the distance between the activity room and the dormitory exit is shortened, the time difference for personnel evacuation from activity units is minimal (Figure 20). At this point, the distance between the exits of some activity units and the evacuation paths of the stairs increases, which leads to a decline in the overall evacuation efficiency. However, when the dormitory exit is set at position 4 and the exit between the activity room and the dormitory is set at position 9, the distance between the exit of the activity unit and the evacuation path of the staircase is relatively short, which enhances the overall evacuation efficiency.

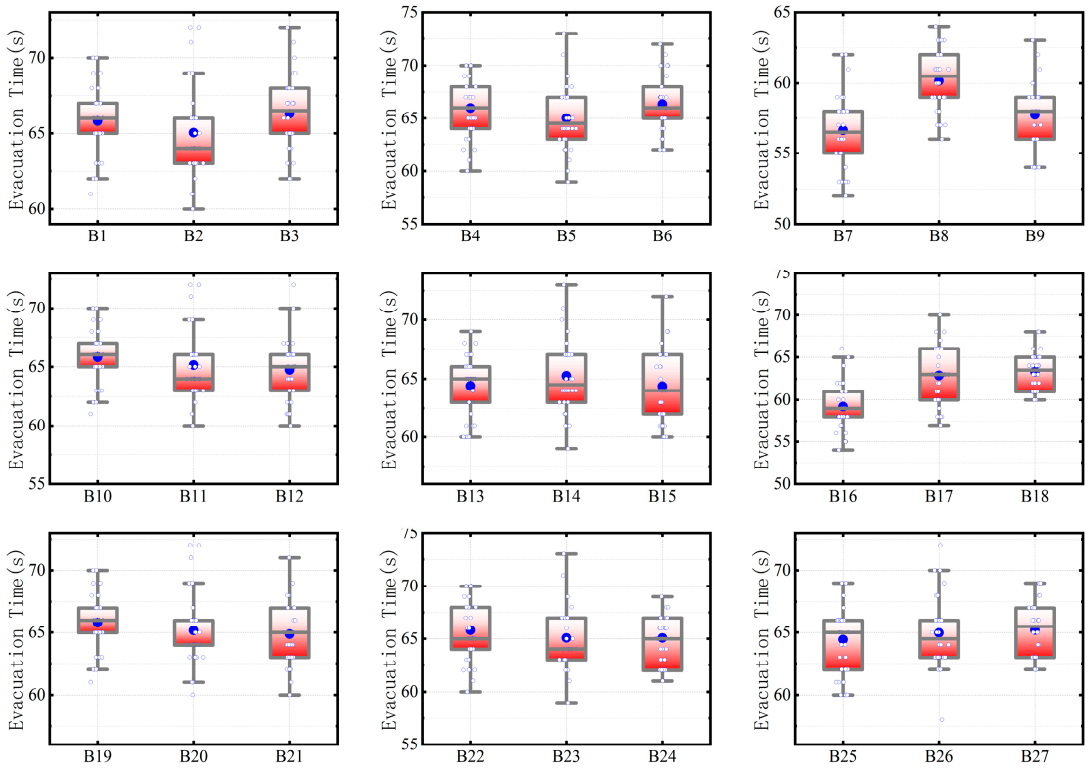


Figure 20. The box diagram and whisker diagram compare the evacuation time data of escaping from activity units between different activity rooms and dormitory exits.

Figure 19 shows that, when the exit of the activity room in the activity unit is set at position 1, reducing the distance between the activity room and the exit of the dormitory has a relatively small impact on the evacuation efficiency by altering the dormitory exit. The reason is that, as the distance between the activity room and the dormitory exit decreases, the time required for occupants to evacuate the activity unit is shortened (Figure 21). However, during the evacuation process, congestion at evacuation bottlenecks such as

corridor and staircase entrances increases (Figure 22). Meanwhile, the average density among the personnel changes relatively little (Figure 23). Therefore, among several schemes to reduce the distance between the activity room and the dormitory exit, the differences in evacuation efficiency are relatively small.

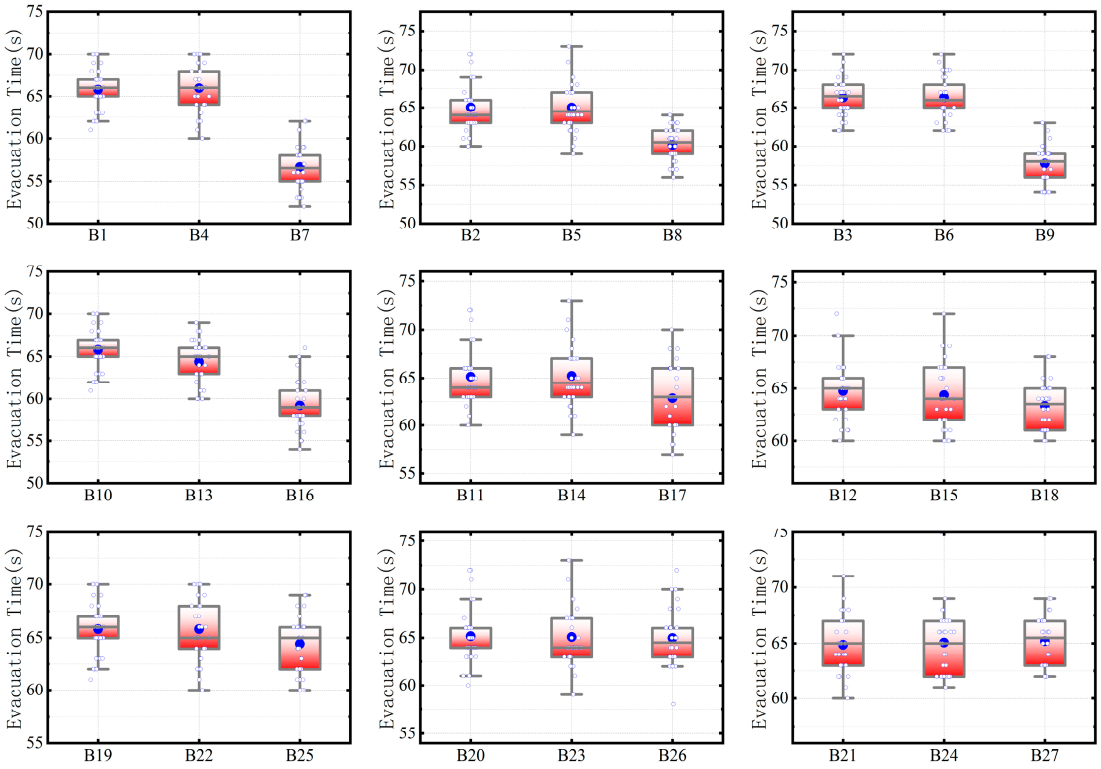


Figure 21. Comparison diagram of evacuation time data for different escape activity units when the exit of the activity room is located at position 1.

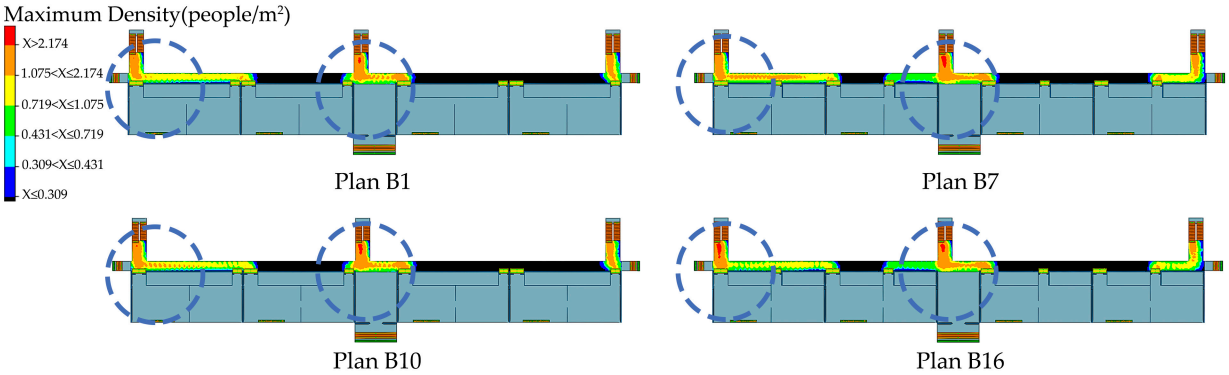


Figure 22. Comparison chart of the maximum evacuation density at corridors B1, B7, B10, and B16 and the staircase entrances.

In the separation model of activity room and dormitory, the combination of "Activity Room Exit Position 1 and Connection Point Position 7" achieves a 10.93–13.13% efficiency improvement by establishing a hierarchical evacuation system. This result verifies the positive effect of spatial division on the optimization of escape routes [60,61]. Notably, the superiority of position 7 as a connection port may stem from its location at the topological center of the connection exit between the activity room and the bedroom, which is highly correlated with the "integration degree" index in Hillier's spatial syntactic theory [62].

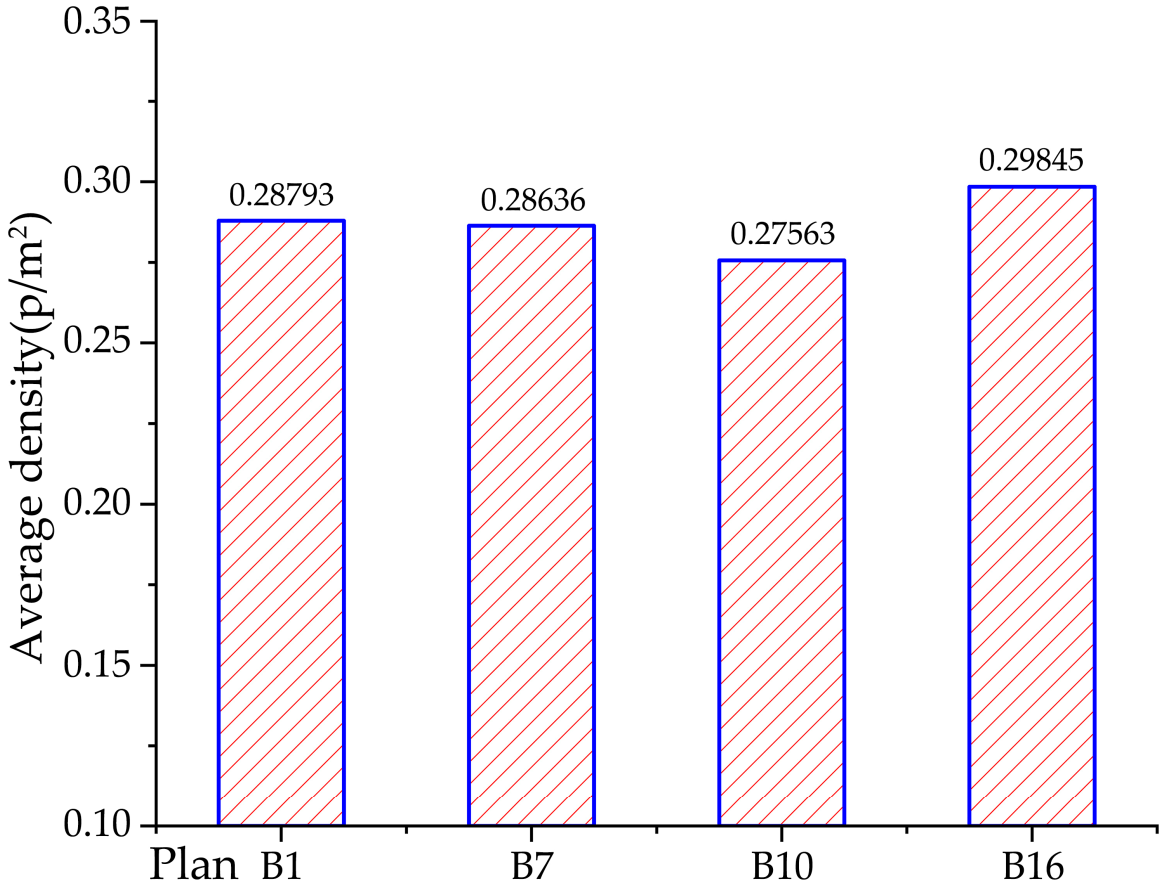


Figure 23. Average density bar chart of the separation and evacuation of activity rooms and dormitories from the building.

The Impact of Exit Locations Connecting Activity Units and Bedrooms on Evacuation Under the Separated Layout of Activity Rooms and Bedrooms

The influence of the exit between the activity room and the dormitory on the evacuation efficiency is similar to setting up obstacles at the exit [63]. This type of obstacle will affect the length of the path for evacuees to reach the exit. When the exit of the activity room is set at exit 1, the layout will prolong the escape path for evacuees from the activity unit. Appropriately increasing the distance between evacuees and exits can, to a certain extent, alleviate congestion in corridors, staircases, and other areas. However, when the distance increases to a certain critical point, the time required for the evacuees to reach the exit is too long, which will instead reduce the evacuation efficiency. When the exit of the activity unit is set at position 2 or 3, the layout design itself shortens the distance for evacuees to reach the exit of the activity room. However, the location of the exit between the activity room and the dormitory has a relatively minimal impact on the choice of exit among evacuation personnel, which leads to increased congestion at the entrances of corridors and staircases. Ultimately, the overall evacuation efficiency is reduced.

4.2. Impact of Furniture Layout on Evacuation

In this study, the evacuation efficiency of the tables and chairs in the activity room with a layout parallel to the exit wall is higher than that of the layout with the tables and chairs perpendicular to the exit wall, and the difference is significant ($p < 0.05$). This result is due to that the parallel furniture arrangement offers superior visibility, whereas the perpendicular arrangement necessitates a brief turning maneuver during escape. This requirement slows down the pace of evacuees reaching the exits of activity rooms and

dormitories. This slowing down alleviates congestion at the exits of activity units, which enhances the efficiency of evacuation.

When non-stowable beds are used in the dormitory, the average evacuation times for vertical bed layouts and parallel exit wall layouts are similar, with no significant difference in evacuation efficiency observed ($p > 0.05$). This result is due to that the number of turns made by the evacuees from the evacuation starting point to the dormitory exit, the line of sight of the evacuees along the evacuation path, and the short escape paths of the evacuees all vary slightly. As a result, the evacuation efficiency is close.

When stowable beds are used in the dormitory, the evacuation efficiency is higher when the combined layout of the activity room and the dormitory adopts the scheme of stowable beds ($p < 0.05$), which is increased by 2.29% compared with that in the worst situation. When the activity room and the dormitory are separate, the stowable beds have a relatively minimal impact on the evacuation efficiency, and no significant difference is observed in the evacuation efficiency ($p > 0.05$). When occupants evacuate via the bedroom exit in the combined layout, the stowable bed configuration results in a significantly shorter escape route from the activity unit compared with the non-stowable bed scheme. Furthermore, the non-storable beds obstruct the line of sight of occupants, which necessitates more turns during evacuation. Ultimately, this option yields lower efficiency than the storable bed option. When activity room and dormitory are combined, a right partition separating them results in similar evacuation routes for occupants. As a result, the evacuation efficiency is not enhanced. In combination with the daily life management of the kindergarten and the unobstructed evacuation routes, the beds in the dormitories should be folded up when in use to improve the evacuation efficiency.

The existing part focuses on the position of desks and chairs in the classroom layout being perpendicular to the exit wall [8,19,33]. Meanwhile, the layout of desks and chairs in the activity room of kindergartens is relatively flexible. Thus, the research results may not be suitable for the layout of desks and chairs in the activity room of kindergartens. The layout of the activity room tables and chairs parallel to the exit wall increases the evacuation efficiency by 4.56%, which is consistent with the theory of path visibility [64]. When furniture axes align with escape directions, children form clearer path recognition. The lack of statistical significance in dormitory bed layouts ($p > 0.05$) suggests that micro-scale bed orientations have limited impact on overall evacuation. Nevertheless, the 2.29% efficiency gain from stowable beds highlights the importance of flexible spatial design.

4.3. Limitations

Our study, while providing valuable insights into activity units evacuation in kindergarten, is subject to several limitations that point to opportunities for future research. First, the MassMotion software has inherent functional limitations. This study primarily simulated crowd evacuation scenarios with children acting independently and did not account for the active guidance and intervention of teachers during emergencies. Additionally, the model does not incorporate panic behaviors and psychological stress reactions, such as competitive pushing or irrational route selection, which can significantly reduce evacuation efficiency and increase disorder. The software currently lacks the capability for parametric modeling of crowd guidance mechanisms and specific crowd crush risk probabilities. This technical bottleneck may be addressed in the future through algorithmic optimizations or integration with specialized crowd risk analysis tools. Second, the impact of furniture arrangement within the activity unit on evacuation was analyzed. Standardized furniture sizes were used. Due to the limitations of research time and cost, it was impossible to dynamically simulate the influence of a wide variety of different furniture sizes on children's evacuation. Third, the geographical coverage of the current sample needs to be expanded

by examining the spatial heterogeneity of evacuation design in kindergarten buildings across northern and southern in China. This particular emphasis will be an important breakthrough direction for subsequent research.

5. Conclusions

In this study on evacuation procedures for kindergarten activity units, we constructed a social force model based on survey data. The relationship between activity unit layout and children's evacuation efficiency within combined activity room and dormitory configurations was also explored. Through this research, we aim to provide a new perspective for optimizing the design of evacuation units in kindergartens to enhance the safety and efficiency of evacuation in emergency situations. Our research conclusions are drawn as follows:

(1) Our study aims to achieve a paradigm shift in kindergarten evacuation research. From the discrete analysis of evacuation 'components' (such as corridors and entrances) to integrated analysis of the 'activity units' as a whole system. As a complete evacuation analysis unit, the focus is on exploring the coupling mechanism between its internal spatial configuration and functional block layout, in order to improve evacuation efficiency.

(2) This study analyzed layouts and evacuation scenarios of activity units in kindergartens, and obtained quantitative evacuation efficiency data of different schemes through Massmotion software. The results show that when the activity unit adopts layout of the activity room and the dormitory is combined, the exit of the activity room is set at position 3 and the exit of the dormitory at position 5, the average evacuation time can be reduced by 13.84% compared with the most unfavorable scenario. If the activity room and the dormitory are separated, the exit of the activity room is set at position 1 and the connection exit between the activity room and the dormitory is set at position 7. In this layout, the average evacuation time can be reduced by 10.93% to 13.13% compared to the most unfavorable scenario, and the dormitory exit can be flexibly set. The comparison shows that the overall evacuation time of the partitioned layout is shorter than that of the combined layout. Among them, the effect of the activity room exits at position 1 and the connection exit at position 7 is particularly significant. In light of the daily management and usage habits of the kindergarten, it is recommended that the connection exit between the activity room and the dormitory be set at position 7. The above simulation results provide quantitative basis and optimization suggestions for the evacuation design of activity units in kindergartens.

(3) This study also analyzed the efficiency of indoor layout on evacuation. In terms of the layout of tables and chairs in the activity room, results have shown that arranging the tables and chairs parallel to the exit wall can increase the evacuation efficiency by 4.56%, that is, reduce the evacuation time by 9.17 s. In terms of the layout of dormitory beds, the difference in the impact of vertical or parallel arrangement of beds relative to the safety exits on the efficiency of personnel evacuation did not reach a significant level ($p > 0.05$), but the use of storable beds could reduce the average evacuation time by 2.29%.

(4) Future research will focus on two areas. On the one hand, the geographical spatial coverage of the research samples will be expanded. For example, conduct research and draw up the floor plan of kindergartens in the south, etc. On the other hand, set up teacher guidance in the model to explore the impact of teacher guidance on children's evacuation. By constructing a ternary interaction model of "person–environment–behavior," combined with virtual reality experiments and behavior trajectory tracking technology, a hybrid research method will be adopted to deeply explore the dynamic correlation between the spatiotemporal distribution characteristics of teachers' guided behaviors and children's evacuation path selection.

Our research findings provide urban planning departments with a scientific decision-making tool for the evacuation and improvement of existing kindergartens. For the management of kindergartens, the appropriate locations of evacuation exits can be selected based on the layout forms of different activity units and the arrangement of indoor furniture, ensuring the safety of children to a certain extent.

Author Contributions: Conceptualization, X.J. and S.M.; methodology, X.J.; software, S.M. and L.C.; validation, S.M. and Y.F.; investigation, S.M.; Y.F. and Y.W.; data curation, S.M.; Y.F. and Y.W.; writing—original draft preparation, S.M.; writing—review and editing, X.J.; visualization, S.M.; supervision, X.J.; project administration, X.J.; funding acquisition, X.J. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

Conflicts of Interest: Author Lipeng Chang was employed by the company Inner Mongolia Zhongyu Aerospace Engineering Planning and Design Company. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Appendix A

Table A1. Basic information of kindergarten survey sample.

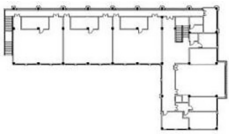
Number	Position	School Name	Schematic Diagram	Floor Area (m^2)	Number of Classes
1	Anqing City, Anhui Province	Government Agency Kindergarten, Country Garden Branch		4642.47	12
2	Chengdu City, Sichuan Province	Zhongye Tianyuan World Kindergarten		1750.86	6
3	Chengdu City, Sichuan Province	Shouchuang International City, South 8 Kindergarten		2429.91	9
4	Dongguan City, Guangdong Province	Dalang Town Art Kindergarten		10,500.4	18
5	Shenzheng City, Guangdong Province	Bao'an District Guanlan Kindergarten		3500.08	12
6	Guangzhou City, Guangdong Province	The kindergarten in District VI of the old village renovation project of Lie De Village		4559	18

Table A1. *Cont.*

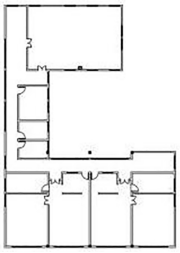
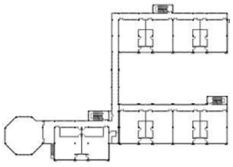
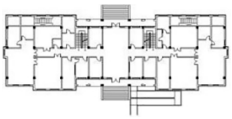
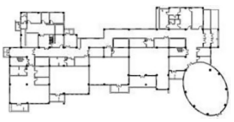
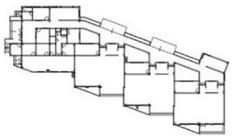
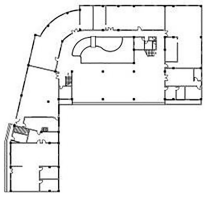
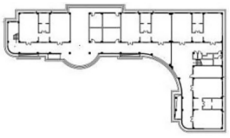
7	Huainan City, Anhui Province	Xincheng Phase II Kindergarten		2255.5	9
8	Jinan City, Shandong Province	The Marriott Center is equipped with a kindergarten		1513.92	9
9	Nanjing City, Jiangsu Province	Jiangsu Academy of Agricultural Sciences Kindergarten		2340.76	9
10	Nanchang City, Jiangxi Province	Best Bilingual Kindergarten		5260.62	13
11	Yingkou City, Liaoning Province	World Trade Crown Garden Kindergarten		2518.42	6
12	Qingdao City, Shandong Province	Shangjing Jiayuan Kindergarten		3904.55	13
13	Shenzheng City, Guangdong Province	Fuying Central Mountain Garden Kindergarten		1860	9
14	Shenzheng City, Guangdong Province	Dongkang Kindergarten		7056	13
15	Nanchong City, Sichuan Province	Yilong County Hongde Kindergarten		2304	14

Table A1. *Cont.*

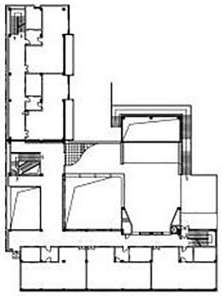
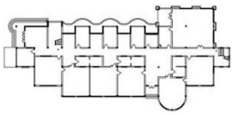
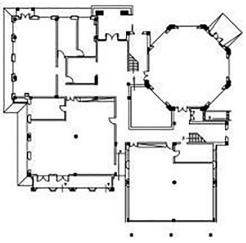
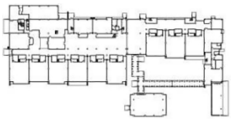
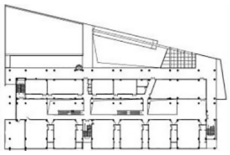
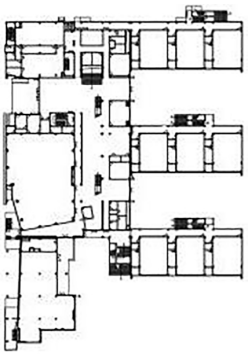
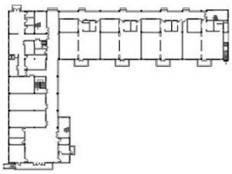
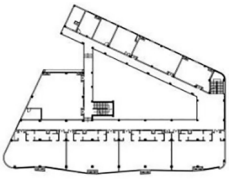
16	Chengdu City, Sichuan Province	Star Kindergarten		2940.06	9
17	Wenzhou City, Zhejiang Province	Shanshui Mingdu Kindergarten		2528	9
18	Wuhan City, Hubei Province	Modern Forest Town Kindergarten		1908.81	6
19	Kunshan City, Jiangsu Province	Fengqi Garden Kindergarten		9794	27
20	Kunshan City, Jiangsu Province	Lucheng Kindergarten		8967	18
21	Wujiang City, Jiangsu Province	Shengze Town Experimental Primary School Kindergarten		17,890	27
22	Dongyang City, Zhejiang Province	Dongyang Municipal Government Kindergarten Jiangbei Branch		6873.4	12
23	Shenzheng City, Guangdong Province	Jingji Kindergarten		1982.3	12

Table A1. *Cont.*

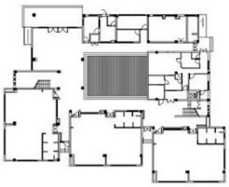
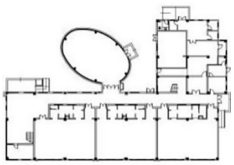
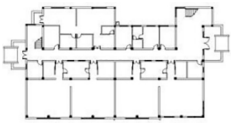
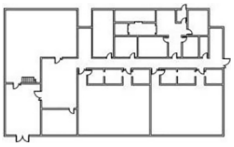
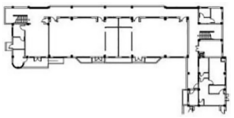
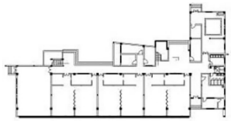
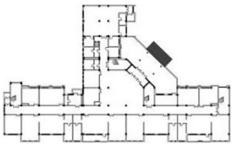
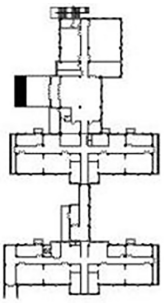
24	Shenzheng City, Guangdong Province	Ligao Kindergarten		1880.97	6
25	Shenzheng City, Guangdong Province	Ligao Kindergarten		3078.48	9
26	Shenzheng City, Guangdong Province	Julong Kindergarten		2022.54	6
27	Hangzhou City, Zhejiang Province	Xingzhi Jintao Kindergarten		1785	6
28	Hohhot City, Inner Mongolia	Huadi Kindergarten		3181.3	6
29	Yueqing City, Zhejiang Province	Wan Jia Kindergarten		2412.6	6
30	Changsha City, Hunan Province	Hongying Wangxin Kindergarten		2114.07	9
31	Wuhai City, Inner Mongolia	Haibowan District Kindergarten		5021	12
32	Wuhai City, Inner Mongolia	Haibowan District No. 2 Kindergarten		5615.89	12

Table A1. *Cont.*

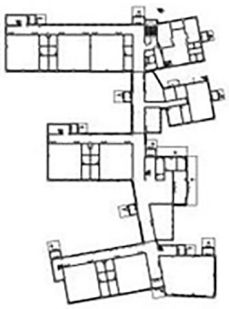
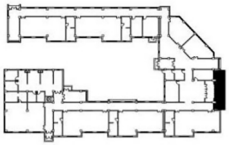
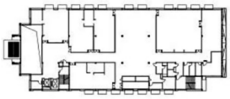
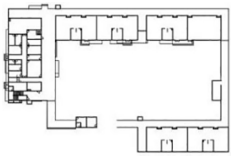
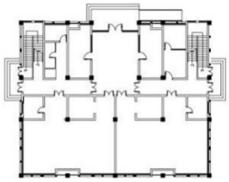
33	Wuhai City, Inner Mongolia	The Fourth Kindergarten of Haibowan District		6596.1	12
34	Wuhai City, Inner Mongolia	Haibowan District No. 6 Kindergarten		6105	24
35	Zhengzhou City, Henan Province	Zhengdong New District Experimental Kindergarten Zhengguang Branch		6114.7	18
36	Beijing City	Chuangshou Yuehui Community Kindergarten		1800	6
37	Chengdu City, Sichuan Province	Zengjiapo Kindergarten		2432.69	9
38	Kunshan City, Jiangsu Province	Kunshan Xinxiuyi Kindergarten		14,535.7	27
39	Zunyi City, Guizhou Province	Fenggang County No. 5 Kindergarten		6592.83	15
40	Hohhot City, Inner Mongolia	Shengle Experimental Kindergarten of Inner Mongolia Normal University		4279.34	10

Table A1. *Cont.*

41	Anyang City, Henan Province	Debao International Famous City Kindergarten		1339.65	6
42	Zunyi City, Guizhou Province	The Second Kindergarten of Tuxi Town		1927.84	4

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