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MODERN APPROACHES TO FORMING THE DESIGN OF CHILDREN'S PLAYGROUNDS

(using the example of China)

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The qualification work contains the results of one's own research
The use of ideas, results and texts of other authors must be referenced to the appropriate source.
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INTRODUCTION

The design of outdoor playgrounds plays a key role in nurturing the holistic development of children. These spaces are not only recreation areas, but also critical environments for physical, cognitive, emotional, and social development. A well-designed playground engages children in meaningful play that stimulates learning, encourages social interaction, and supports healthy physical activity. Because children's developmental needs vary significantly across age groups, designing age-appropriate playgrounds that meet these needs is essential to creating a safe, enriching, and stimulating environment. In recent years, the focus of playground design has moved beyond basic play structures to include innovative design elements that encourage deeper interaction. This has led to an increased emphasis on understanding children's developmental stages and designing playgrounds that accommodate their physical abilities, cognitive challenges, and social interactions. For example, using elements of sensory play for younger children and more complex complex structures for older children helps create an inclusive environment that supports development at every stage. Furthermore, the role of playgrounds goes beyond physical play, as they are crucial to the development of a child's social and emotional well-being. Outdoor play allows children to explore risk in a controlled environment, develop confidence and learn important social skills such as communication, cooperation and conflict resolution. Playgrounds serve as a space where children form relationships, negotiate roles, and engage in creative play that promotes their emotional resilience and social maturity. This research focuses on how playground design can be optimized to meet the diverse needs of children aged 0-12 years. By examining the psychological, cognitive, and physical characteristics of children across age groups, this research aims to identify key design principles that can be applied to create engaging, safe, and developmentally appropriate play environments. This research focuses on the use of innovative design techniques, such as fold line design, which can improve spatial perception and interaction. This design approach, along with others such as bionic and rectilinear design, will be evaluated

for their effectiveness in creating playful, educational and dynamic spaces. Furthermore, the research will consider how these different design methods can be harmoniously integrated to create a play environment that is not only functional but also aesthetically pleasing. The research will rely on an interdisciplinary approach, combining knowledge from child development theory, ecological design and architectural principles. Through a comprehensive review of existing literature, case studies of successful playground projects, and direct field observations, this research will provide a framework for understanding how playgrounds can best support children's development and offer practical design solutions for creating engaging outdoor spaces. Ultimately, this study aims to contribute to the broader discourse on child-friendly urban environments by emphasizing the importance of thoughtfully designed playgrounds in promoting the well-rounded, healthy development of a child.

1.1. State of research on the topic

The basis of this study is a detailed review of the literature, which examines the needs of psychological, cognitive and physical development of children at different age stages (0-3, 3-6, 6-12). It also includes a study of existing playground design principles and case studies from various fields such as urban design, child psychology and educational theory. Summarizing findings from academic research, government reports and design guidelines, the review identifies key elements that contribute to the effectiveness of playgrounds in supporting children's development. In particular, the literature review focuses on how outdoor playgrounds can meet the specific needs of each developmental stage. Studies of sensory development, motor skills and social interaction form the theoretical basis for the age-related design of playgrounds. In addition, the review examines various design techniques, including complex design, and their role in enhancing play spaces for cognitive and physical activity.

Playground design must take into account a variety of opportunities for playing alone: climbing, swinging, sliding. Active solitary play can contribute to: the many benefits of physical activity; motor development; child coordination; self-confidence. There are cases when a child wants to play with other children, but feels insecure around them. This type of play is called “restrained play” because of the child’s reluctance to join in playing with other children. The reasons for this reluctance to play are: the child’s anxiety due to bullying by adults or other children; shyness when participating in new situations; social skills may be lacking due to language problems or limited understanding of others (for example, children with autism and other developmental disorders) [30].

Children’s physical activity has long been the primary focus of outdoor playspace design. Other influences are adult views on risk and economic considerations. However, a growing body of research shows young children’s perspectives on their outdoor playspaces need to be accounted for. Positioned within a mixed-method comparative case study, this paper showcases the stories that young children have told during participatory research about two different early childhood outdoor playspaces. Recurrent wellbeing themes emerged highlighting children’s agency, place attachment and the need to hide. Analysis of the children’s stories indicated that a spacious open-ended environment, with significant natural features, selected built equipment and secluded spaces, fostered children’s experiences of wellbeing through play. Overcrowding, and a preponderance of artificial surfaces and materials appeared to work against children’s wellbeing. The findings indicate that good outdoor playspace design acknowledges the importance of place in children’s lives, and involves them in co-construction of their playspaces [26].

Making playspaces inclusive has predominately focused on internal design, addressing factors that constrain play experiences within these spaces for children with diverse impairments and their families. Less attention, however, has been paid to the journey to the site and how that may influence the decision to visit these environments. This paper contributes to this area by discussing the experiences of

10 children with diverse mobility impairments, aged 9–12-years-old, and their families from south-east Queensland, Australia. This person–environment study of their journeys to playgrounds illuminates the role getting to the site and entering the site plays in shaping decisions to actually visit playspaces. The findings also identify key considerations applicable to open space planning and site planning, towards achieving inclusive landscapes for play [31].

In early childhood education, the outdoor environment is generally recognised as a significant and essential component of the curriculum for young children, having the potential to foster, and extend all aspects of development. In particular, in outdoor environments children can experience a greater sense of freedom than is generally possible indoors in early education settings. Additionally, children can experience nature and interact with elements of the natural environment outdoors. Some evidence, however, suggests that early childhood teachers may underestimate and undervalue the importance of outdoors for children's development. Implications of these findings for children and teachers are considered [10].

In this paper critically examines questions of inclusive design and planning to encourage children's spatial mobility in public spaces. This perspective is based on three interrelated premises: first, public space must be inclusive for children and youth, and their spatial mobility in civic events, activities and gatherings must be encouraged via planning and design. Second, an intergenerational perspective is indispensable to the task of rejuvenating lost public space for the young. Third, a participatory approach to the planning and design of the public realm is central to the creation of an inclusive environment. The paper identifies design attributes of public spaces that encourage children's mobility and emphasises the need for children's active participation in decision making [13].

Origami has enabled new approaches to the fabrication and functionality of multiple structures. Current methods for origami design are restricted to the idealization of folds as creases of zeroth-order geometric continuity. Such an

idealization is not proper for origami structures of non-negligible fold thickness or maximum curvature at the folds restricted by material limitations. For such structures, folds are not properly represented as creases but rather as bent regions of higher-order geometric continuity. Such fold regions of arbitrary order of continuity are termed as *smooth folds*. This paper presents a method for solving the following origami design problem: given a goal shape represented as a polygonal mesh (termed as the *goal mesh*), find the geometry of a single planar sheet, its pattern of smooth folds, and the history of folding motion allowing the sheet to approximate the goal mesh. The parametrization of the planar sheet and the constraints that allow for a valid pattern of smooth folds are presented. The method is tested against various goal meshes having diverse geometries. The results show that every determined sheet approximates its corresponding goal mesh in a known folded configuration having fold angles obtained from the geometry of the goal mesh [15].

1.2. Research methods

The research methodology for this study is designed to comprehensively analyze children's growth needs and their implications for the design of outdoor playgrounds, as well as the specific design methods used to create effective and attractive play spaces. Given the interdisciplinary nature of this research, spanning child development, environmental design and architectural theory, the methodology uses both qualitative and quantitative approaches to ensure a holistic understanding of the research subject.

Of particular importance for the research was the *ecological approach*, which contributed to the analysis of children's playgrounds in accordance with the complexity of their functional content and taking into account their location. At various stages of the work, a *measurement method* was used, thanks to which information was obtained about the nature of playing activities by children of different age categories. Further elaboration of the research was carried out using the *method of analogies*, which was reflected in the consideration of the design of

game spaces то determine the conceptual and terminological apparatus regarding the formation of children's play spaces in the conditions of development. *Comparative-analytical* and *typological methods* (systematization and classification) were used to determine the main types of playgrounds, their characteristics and advantages. The *visual-analytical method* contributed to the identification of approaches, principles and techniques for the formation of the design of game spaces, taking into account the modern requirements of their organization. During the analysis of specific children's play objects, *the methods of functional, constructive-technological, ergonomic, figurative-stylistic, artistic-compositional analyzes* were used. The field *observation method*, which is an important part of this study, was used to observe the behavior of children aged 0 to 12 years, so that key aspects of children's behavior such as: their use of playground equipment, issues of social interaction with peers, and reactions to various types of gaming activities - were carefully analyzed. The *method of behavioral analysis* was used to determine the patterns of children's play preferences, levels of physical activity, and the development of social and cognitive skills in response to various features of the design and organization of the playground.

Conclusions to the first chapter

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SECTION II. THE NEEDS OF CHILDREN'S GROWTH AND THE SIGNIFICANCE OF DESIGN

2.1. The role of open playgrounds in supporting the many needs of a child's growth

Outdoor playgrounds are an important environment that promotes the holistic development of children. They are much more than places of recreation, they are an integral part of physical, cognitive, emotional and social development. Playgrounds help children develop important life skills in a natural, unstructured environment. Professionally designed playgrounds support different aspects of development by providing a variety of activities and play elements that meet different developmental stages and needs. Particular attention is paid to how children engage with specific design elements such as sensory play structures, climbing equipment and obstacle courses.

Physical development of the child. One of the main functions of outdoor playgrounds is to support the physical development of children. Outdoor playgrounds offer children the opportunity to participate in activities that promote motor skills, balance, strength and coordination. Features such as climbing structures, slides and swings challenge children's gross motor skills, while smaller elements such as balancing bars and object grabbers improve their fine motor skills [1]. Natural features in playspaces, such as hills and vegetation, promote both structured and unstructured physical play, which is more beneficial for developing motor skills compared to indoor environments [2].

- *Gross Motor Development*: climbing, running, rocking and sliding help children develop their large muscle groups, improving coordination, strength and balance. These activities provide the exercise needed to maintain a healthy body weight, build muscle, and strengthen the cardiovascular

system. Fine motor development: Playgrounds can also help develop finer skills such as grasping and manipulating objects. Play elements that require children to grab ropes, push swings, or handle small objects help improve hand-eye coordination and drawing skills as they grow older.

Cognitive development. Outdoor playgrounds are places where children engage in problem solving, experimentation, and creative thinking. Orienting themselves in various game structures, children naturally encounter problems that require cognitive processing. Playgrounds encourage curiosity and exploration, which is critical for cognitive development. Furthermore, outdoor environments contribute to children's sensory development, as they are exposed to different textures, sounds, and sights that cannot be replicated indoors. Sensory-rich environments are especially important for toddlers and preschoolers, as they stimulate brain development and support the formation of neural connections [3]. This reinforces the importance of incorporating natural elements into playspace design, as these features foster a more dynamic and stimulating play environment [4]. Research has found that natural playspaces, in particular, encourage more imaginative play, which is linked to higher levels of creativity and problem-solving abilities in children [5]. For example, children who regularly play in environments with loose parts, such as sticks and stones, exhibit greater creativity and adaptability in play scenarios compared to those who play in structured, artificial playgrounds [6].

Moreover, outdoor play provides opportunities for risk-taking, which is vital for cognitive development. Engaging in challenging activities, such as climbing trees or navigating uneven terrain, teaches children to assess risks, make decisions, and develop resilience [7]. This type of play fosters critical thinking and helps children develop a sense of autonomy and confidence in their decision-making abilities [8].

- *Problem Solving and Decision Making*: By choosing how to interact with different equipment, such as deciding the safest way to climb or determining

the best route on an obstacle course, children engage in decision making and critical thinking. This experience helps them develop problem-solving skills that will be needed in everyday life.

- *Creative play:* Many playground elements, such as sandboxes, playhouses and open spaces, allow children to use their imaginations. Unstructured play encourages creativity as children create their own games, roles and narratives, which improves cognitive flexibility and abstract thinking.

Emotional and psychological development of the child. Playgrounds also serve as safe places for emotional expression and regulation. Outdoor play allows children to experience a range of emotions—from excitement and joy to frustration and determination—as they engage in a variety of activities. Research indicates that children who have access to natural playspaces exhibit lower levels of anxiety and are better able to cope with emotional challenges [13]. Natural environments, with their calming and restorative qualities, provide a respite from the overstimulation often experienced in indoor settings [14].

Moreover, outdoor play offers children opportunities to experience a sense of freedom and autonomy, which is essential for building self-esteem and emotional well-being. In these spaces, children have the freedom to explore, take risks, and make decisions independently, which fosters a sense of competence and confidence [15]. These emotional benefits are particularly important in early childhood, as they lay the foundation for healthy emotional development throughout life [16].

In conclusion, outdoor playspaces play a pivotal role in supporting the holistic development of children. By providing opportunities for physical activity, cognitive challenges, social interaction, and emotional growth, these environments are integral to children's overall well-being. Designing playspaces that incorporate natural elements, promote inclusivity, and encourage unstructured play can significantly enhance the developmental benefits of outdoor environments. As such, it is crucial for educators, parents, and designers to recognize the importance

of these spaces and advocate for their inclusion in early childhood education and urban planning.

- *Building confidence and independence*: Successfully completing challenges on the playground, such as climbing to the top of a structure or mastering the use of a swing, gives children a sense of accomplishment. This helps build their confidence and encourages them to take on new challenges, promoting independence and resilience.
- *Emotional regulation*: Playgrounds provide an environment where children can release energy and manage their emotions. Play is a natural way for children to cope with feelings of anxiety or stress. They learn to express emotions and develop coping mechanisms, such as learning to wait their turn or deal with the frustration of falling during a game.

Social development. Playgrounds are social spaces where children interact with peers, which is important for the development of communication, cooperation and conflict resolution skills. These interactions help children learn important social behaviors and etiquette. Natural playspaces, in particular, tend to encourage more cooperative and collaborative play compared to traditional playgrounds with fixed equipment [9]. Studies have shown that children who engage in play in natural settings are more likely to engage in group activities, negotiate roles, and share resources, which are essential for developing social competencies [10].

Additionally, outdoor play fosters social inclusion, as these spaces provide a neutral ground for children of different ages, abilities, and backgrounds to interact. Research has highlighted the importance of designing inclusive playspaces that cater to diverse needs, ensuring that children with disabilities can fully participate in social play [11]. Inclusive design strategies, such as the use of ramps, accessible play structures, and sensory play elements, allow all children to engage in meaningful social interactions [12].

- *Cooperation and teamwork*: Group play activities such as team games or shared equipment such as swings teach children how to cooperate, share and

work towards common goals. These experiences are fundamental to developing lifelong teamwork and cooperation skills.

- *Conflict Resolution and Communication*: Conflicts or disagreements may arise during play, such as who gets to use the swing next. In such situations, children learn to negotiate, express their feelings and resolve conflicts with others. This helps them develop social skills and emotional intelligence.
- *Role play and empathy:* Playgrounds often encourage creative play where children take on different roles, such as pretending to be superheroes or playing family roles in a playhouse. Role playing develops empathy by allowing children to see the world from different perspectives.

The importance of safety and risk for a child's growth. Outdoor playgrounds provide a balanced environment where children can engage in controlled risk-taking activities that are essential for learning and growth. It is important for children to face manageable risks, such as climbing higher or overcoming a more difficult obstacle, in a safe environment.

- *Learning through risk:* By trying new challenges, such as climbing higher on a structure or balancing on a narrow beam, children learn about their physical limitations and capabilities. Taking risks in a controlled environment allows them to develop self-assessment skills, learn what they can safely achieve and boost their confidence.
- *A safe environment:* Despite the importance of risk, safety must also be a priority in playgrounds. Properly designed playgrounds include safe surfaces, such as rubber or sand, and equipment that meets safety standards to reduce the risk of injury. This balance ensures that children can explore and challenge themselves in a safe and secure environment.

It is worth noting that the study of **psychological and behavioral characteristics of children in relation to age categories is no less important.** Children's developmental stages are closely related to their psychological and behavioral characteristics, which in turn influence the design of outdoor play

environments. Understanding these traits at different age levels helps create a space that not only engages children, but also promotes their growth in various areas such as cognitive, physical, emotional and social development. This section examines the distinguishing characteristics of children in the three initial age groups—0–3 years, 3–6 years, and 6–12 years—and relevant design considerations for each group.

Inclusive Design Considerations

Inclusive design in children's playspaces aims to ensure that children of all abilities can equally participate in play, fostering both physical and social inclusion. The growing recognition of children's rights to play, including those with disabilities, has led to significant research and policy changes regarding how these spaces should be designed. However, challenges remain in fully realizing inclusive playspaces that cater to the diverse needs of all children. This section explores the key considerations and strategies for inclusive design in playspaces, drawing on extensive research and examples from around the world.

Inclusive playspaces are not only about physical accessibility but also about promoting social inclusion. Research has shown that well-designed inclusive playgrounds foster social interactions among children with and without disabilities, helping to break down social barriers and promote empathy and understanding [23]. For example, in an Australian study of an inclusive playground, families reported that the space promoted feelings of safety, welcome, and belonging, which are critical for creating a socially inclusive environment [24].

Additionally, inclusive playspaces should provide opportunities for cooperative and parallel play, where children can engage in activities both independently and together. This is particularly important for children with autism, who may struggle with social interactions but still benefit from being in the presence of others in a shared environment [25]. By designing spaces that encourage different types of play, inclusive playgrounds can cater to a wide range of social needs and preferences. For example, incorporating feedback from children with mobility impairments can lead to the inclusion of more accessible paths, ramps, and play

structures, while input from children with sensory processing disorders can inform the integration of sensory elements [28].

Universal Design and Accessibility

One of the core principles of inclusive design is the application of universal design concepts, ensuring that playspaces are accessible to all children, regardless of their abilities. Universal design aims to create environments that are usable by all people, to the greatest extent possible, without the need for adaptation or specialized design. Studies have shown that applying universal design in playspaces not only benefits children with disabilities but also enhances the play experience for all users [17]. For example, inclusive playgrounds designed with ramps, sensory play elements, and accessible equipment allow children of different physical abilities to engage in play together, promoting social interaction and inclusion [18].

However, many public playgrounds continue to fall short of these standards. Research conducted across European countries highlighted a significant lack of policies that enforce universal design in playspaces, with many playgrounds still inaccessible to children with disabilities [19]. In response, several countries have begun implementing guidelines that incorporate universal design principles, but more widespread adoption is needed to ensure that all children have access to inclusive play environments [20].

Challenges and Future Directions. Despite significant progress, there are still challenges to implementing fully inclusive playspaces. One of the major barriers is the cost associated with retrofitting existing playgrounds to meet universal design standards. Additionally, there is often a lack of awareness or knowledge among designers and local authorities about the principles of inclusive design, leading to playgrounds that may meet basic accessibility requirements but fail to provide meaningful play opportunities for all children [29].

To address these challenges, more research is needed on the long-term impact of inclusive playspaces on children's development and social inclusion. Furthermore, training programs for designers and planners should emphasize the importance of inclusive design and provide them with the tools and knowledge necessary to

create truly inclusive environments. Collaboration between designers, occupational therapists, educators, and families will be key to advancing the field of inclusive playspace design [30].

Inclusive playspaces are essential for ensuring that all children, regardless of their abilities, can access the benefits of play. By applying universal design principles, incorporating sensory elements, and promoting social inclusion, designers can create environments that foster physical, cognitive, and emotional development for all children. Community involvement in the design process is crucial for creating responsive and effective playspaces that meet the diverse needs of the population. While challenges remain, ongoing research and advocacy for inclusive design will continue to improve the accessibility and inclusivity of public playspaces.

2.2. Study of the issues of active or passive recreation of children in relation to their age categories.

Ages 0-3: Exploration and sensory development. Children 0-3 years old are in the stage of rapid sensory and motor development. During this time, they are mainly engaged in activities that help them explore their environment and develop basic skills such as crawling, walking and grasping. Sensory experiences are especially important because children at this stage rely heavily on touch, sight and sound to make sense of the world around them.

Playgrounds for this age group should be designed to stimulate their sensory perception while ensuring safety. Activities such as playing with sand, mud and water are crucial for sensory development. These materials offer different textures and physical properties that help children understand concepts such as volume, consistency, and cause-and-effect relationships. Features like swings and slides also provide important sensory feedback. The swing motion helps children develop a sense of balance and body awareness, while the slides help with coordination and timing. However, since children in this age group are still developing motor control, these activities require adult supervision to prevent injuries. Crawling is a

key motor skill at this stage, and playground features such as turf slopes and walk-through tunnels provide a safe and stimulating environment for children to develop this skill. Soft surfaces and low-slung equipment minimize the risk of falling, allowing children to explore freely. Additionally, providing small tricycles allows children to develop leg strength and coordination as they experiment with self-propelled movement. Fine motor skills such as grasping and manipulating objects also develop at this stage. Equipment that encourages the use of three fingers, such as small pens or interactive panels, helps children strengthen their hands and fingers. Walking and jumping, such as tiptoeing and jumping over small obstacles, help develop balance and coordination, which is critical as children progress to more advanced motor skills. Swing equipment, such as spring rides, offers children another way to experience movement and develop their vestibular systems, which are crucial for balance and spatial orientation.

Ages 3-6: Social awareness and group play. When children reach the age of 3-6 years, their play behavior changes from solitary and sensory-oriented to more social and interactive forms of play. During this period, children begin to develop social awareness and more often participate in group activities. They begin to form relationships with peers, and their play reflects a growing understanding of social norms such as sharing, taking turns, and cooperating with others. Playgrounds designed for this age group should promote social interaction while continuing to support physical and cognitive development. At this stage, balance and coordination are improved, and playgrounds can include features that challenge these skills. Balance boards, for example, help children maintain stability when walking on narrow surfaces, improving their motor control. In addition, activities such as roller skating or obstacle courses help develop coordination and agility by requiring children to plan their movements and adjust their balance according to changing conditions. These activities not only promote physical development, but also encourage teamwork and problem solving when children participate in them together. Play structures for climbing become especially important for children of this age group. As their strength and coordination

improve, they seek out more challenging physical tasks, such as climbing ladders, ropes, or rock walls. Climbing helps develop upper body strength and improves spatial awareness as children have to judge distances and make decisions about where to place their arms and legs. It also offers opportunities to take risks in a controlled environment, which is important for building confidence and resilience. Slides remain a popular feature for this age group, but they take on added value as children begin to interact with their peers. Sliding is often a social activity where children take turns or compete against each other. This introduces elements of social negotiation and cooperation as children must navigate the rules of the game and manage their interactions with others. The simple act of sliding down together can foster friendships and foster a sense of community among young children.

Ages 6-12: Developing social skills and group interaction. Children between the ages of 6 and 12 are at a stage of significant cognitive and social development. They are more adept at navigating complex social situations, and their play often involves larger groups and more structured activities. During this period, children begin to develop specific social skills, such as leadership, negotiation, and conflict resolution, which are important for interacting with peers and adults. Playgrounds designed for this age group should offer opportunities for group interaction and cognitive challenges, as well as physical activity that continues to support their growing bodies. Cognitive development is central for children of this age. They are capable of engaging in more complex problem-solving tasks and are often drawn to games and activities that involve strategy, such as puzzles or interactive board games, that require them to think critically. Obstacle courses, for example, provide a physical challenge that also requires cognitive planning, as children must determine the best way to move through various elements. These activities help improve executive skills such as planning, attention, and task switching, which are critical for academic success and everyday decision-making. Ball games are another key component of playgrounds for this age group. Whether they're playing soccer, basketball, or tag, kids learn important social skills through team activities. Ball games teach them how to communicate

effectively with teammates, follow the rules, and resolve conflicts that may arise during competitive play. These games also promote physical fitness by encouraging running, jumping and hand-eye coordination. Importantly, group sports offer opportunities for leadership development as children take on roles such as team captains or referees, learning to lead and support others. In general, playgrounds for children aged 6-12 should include a variety of activities that promote both physical and social development. Emphasis on group play. interaction helps children improve their social skills, while incorporating cognitive challenges ensures children's continued engagement in learning and personal growth.

2.3. Basic approaches in deciding the design of children's playgrounds.

To further confirm the findings in the literature, this study includes case study analysis of existing playgrounds that successfully integrate child-centered design elements. These case studies were selected based on their ability to address the psychological and behavioral characteristics of children through innovative spatial planning and equipment. Each example is evaluated based on criteria such as safety, interactivity, accessibility and age appropriateness. In particular, playgrounds that use modern approaches in their design, such as (tabl.B.2.3.1.):

- *folded approach in design* (Fig.A.2.3.1.- Fig.A.2.3.4.);
- *linear (straight-line, spiral or curved) approach* (Fig.A.2.3.2.- Fig.A.2.3.4.);
- *bionic approach in site design* (Fig.A.2.3.5.- Fig.A.2.3.13.);
- *geometric approach in solving the design of the playground* (Fig.A.2.3.15.- Fig.A.2.3.16.);
- *parametric approach in playground design* (Fig.A.2.3.17.- Fig.A.2.3.18.).

All of the above approaches are carefully researched to assess their impact on children's engagement and developmental progress. Case studies of visual material serve as practical examples of how theoretical concepts are applied in real-world

settings. They provide concrete evidence of the effectiveness of specific design strategies in promoting physical, cognitive and social development. In addition, the analysis helps identify potential problems and opportunities for improvement in the playground design, offering information that informs the final design proposal. So, let's consider the best examples of children's playgrounds.

- ***A folded approach to design.*** A clear example is the activity of specialists in creating a children's play space from the Lab D+H company. The main element of the formation of this site is the multi-level relief of Folds (fig.A.2.3.1.). This approach in the design of playgrounds is proposed as an idea of returning to the basics of the foundation through the folding-unfolding of terrain gaps. The authors of the project consciously minimize the use of specialized equipment for children's playgrounds, because the complex shape of the relief can encourage children to perceive space tactilely. Located on a street corner, the Folds relief is part of a larger streetscape system in a mega-housing complex (400,000 sq m) in Changzhou, China. The streetscape system includes a series of public gardens and small spaces. The relief of the territory itself and the public garden was the starting point for the development of the children's play space project. Children can decide for themselves how to have fun: run, climb, play hide and seek, etc. The terrain construction begins with a rolling lawn element, which later transforms into complex bamboo wood decks of varying heights and accented with colored metal grid frames. Functionally, taking into account the ergonomic dimensions of children, the constructions are harmoniously designed and allow solving the factors of surprise, because after opening a cave under some folds, children enter the unknown world of the proposed game. The consistency of the territory on which the children's playground is proposed inspired the designers to conduct research on the possibility of combining the artificial, multi-level relief of the landscape created by them with "clean space". It seems to become an addition to the main territory of the street in accordance with its scale, the height of the relief changes, the special atmosphere and textures of the materials used. Thus, the

behavior of children's play activities naturally arises in the interaction between passers-by and the environment.

- ***Linear (straight-line, spiral or curved) approach.*** A good example of this approach is the playground called "Cool ring", which is one of the components of the Play Rings series of game equipment, carefully developed and prototyped thanks to extensive scientific research and development by various specialists (fig.A.2.3.2.) . The play equipment is designed for users of different ages and levels of physical and mental development, and the Fun Rings elements in the proposed composition provide a safe but challenging play environment that encourages children of all ages to experiment while playing. As the analysis of this material shows, this approach in the formation of the design of game equipment contributes to the development of children's physical, social, communicative and teamwork skills. All these characteristics are fundamental for the normal growth and development of children and adolescents. According to the concept of the authors of the project, learning in the form of play is central in determining the approaches to the formation of a children's playground, where the main ones are controlled and uncontrolled (spontaneous) game actions in a special children's environment. This type of learning in the form of a game, according to psychologists, is very effective; it helps:

- creating a children's environment with a low level of anxiety;

- encouraging children to actively engage and gain new experience;

- to facilitate interaction between peers and adults in an interesting playful form of communication and communication.

From the point of view of neuroscience, teaching children in a playful way significantly improves their cognitive skills, where, using previous experience, they have the opportunity to develop interconnected processes in the brain with the development of the next more complex game tasks. Experts say that in order to maximize the results of play-based learning, a play-based learning environment

should embody characteristics such as joy, meaningfulness, active involvement of children of all ages, and the development of social interaction. Designed for 10-14 year olds, Cool Ring is aimed at a group of children known as "cool kids" who are looking for more challenging and fun play activities. The main characteristics of the Cool Ring equipment are the possibility of simplifying or complicating game activities by creating specialized areas for working out strong physical exertion with activities of higher complexity (ping-pong tables, climbing arches, revolving slides, basketball rings and hanging bars). With an emphasis on creating a design for a visually exciting play space, the specialists envisioned the inclusion of equipment in the play space that facilitates interaction with social networks (places for selfies in giant glasses) and possibilities for using board games.

Made of a stainless steel frame and covered with steel sheets painted with fluorocarbon, the children's space with Cool Ring equipment ensures durability and safety of its use. Some elements and equipment are made of fiberglass, and the maximum height of the Fun Ring equipment elements reaches 4420 mm. In addition, the project authors' emphasis on social involvement not only improves children's interpersonal relationships, but also promotes the development of such important skills as communication, cooperation and empathy, laying the foundation for positive social behavior in the future.

Incorporating Fold-line Design into Playspaces Fold-line design, a concept that originally originated in architectural and urban planning theories, is increasingly gaining recognition for its innovative approach to creating dynamic, flexible and engaging play spaces. The fold line design method allows for the development of angled continuous lines or "folds", which helps to create spatial configurations that differ from traditional rectilinear or curved structures. This technique improves spatial perception of the environment, creates opportunities for dynamic play and promotes engagement by offering children a varied and stimulating physical environment.

- ***Bionic approach in playground design.*** Biomimicry, or the design of systems and structures inspired by nature, has proven to be very effective in the context of play space design (fig.A.2.3.5). By mimicking the organic shapes and patterns found in nature, designers can create environments that are more intuitive and engaging for children. One common use of biomimetic design in playgrounds is to incorporate naturalistic elements such as tree-like structures, rock formations, or leaf-like canopy structures. These features not only create physical difficulties for children, but also contribute to cognitive and emotional interaction through interaction with the natural environment [31]. In addition, biomimetic assembly methods commonly used in deployed structures in aerospace engineering are being adapted for playgrounds to create flexible, lightweight, and sustainable materials. For example, triangular and hexagonal folding patterns inspired by leaf structures can be used to create modular, adaptive spaces that can be changed according to user needs [32]. The potential of such biomimetic structures lies in their ability to combine function with form, offering natural aesthetic beauty and utility in playgrounds.

An interesting example is the design of the playground, which has the image of a dynamic bamboo Chinese dragon made of woven wooden strips, gracefully lying on the playground. This playground combines elements of Chinese national culture, mythicity, the function of playing in an open space and the expressiveness of the bionic approach in the formation of the artistic image of the playground (fig.A.2.3.8.).

The following example of the bionic approach indicates the possibility of the authors of the project creating a bright area for international tourism that emphasizes the harmony of the natural world. With the help of landscape architects, product designers, sculptors, installation artists, scientific experts, ecological restoration experts and mechanical specialists, the designers propose playful elements in addition to basic architectural forms that coexist in harmony with the environment, emerging from the ground. The biodiversity of this area will be reflected by them in different ways. The world will begin to perceive, touch and

reach the maritime culture of the East China Sea. The incomparable unique culture of the fairy land of Penlai can be clearly seen, well understood and spread as a corner of the amazing culture of China (fig.A.2.3.9.). More interesting things can be found in the octopus's huge head. Each and every section is connected by the crawling nets like neural networks. Through the multi-color turnplate, the sunshine displays various colors. The little children call out to their friends on the beach through the microphones (fig.A.2.3.10.). The little children have access to everything possible in the Wolong Valley. The body of the dragon can serve as a trestle for children to race, the scales as ropes to ensure their safety, and the claws as secret paths for them to explore (fig.A.2.3.11.).

The design concept of the next inro playground named Butterfly Cocoon comes from a high level of synchronization and alignment between universal design requirements and the client's sense of mission for children's playgrounds. This is of great importance for the formation of the design of public playgrounds, which are truly impressive considering the social responsibility of citizens (fig.A.2.3.12.- fig.A.2.3.13.). The design of the play equipment takes into account the growth stages of children, so the height of the butterflies is different in relation to their growth. Other natural and scientific knowledge is provided in the form of various cocoon figurines and, with the help of holographic lighting, the elements of the child's interaction with the equipment allow to obtain various knowledge in a more interesting way. In addition, in the design of the images of butterflies and cocoons, several important tasks for raising children in a playful way are also considered.

- ***A geometric approach*** in solving the design of a children's playground. The geometric approach has always played an important role in architectural design, but its application in the design of the game space has acquired a new dimension with the advent of computational design tools:

- *Origami*, the art of paper folding, became the main source of inspiration for designing modular and flexible playground elements. The playground, created on

the basis of the origami paper technology, is called so because it looks like a sheet of art paper folded into a crumpled stone sculpture. For example, Jurong West's origami playground is designed for climbing, thanks to its clear lines, similar to paper folds (fig. A2.3.14). When you get closer to it, you can see the multi-colored handles of the game structure for climbing on the walls. Using geometric folding patterns, designers can create complex, multidimensional structures that can change shape and function depending on how they are folded or manipulated [33]. These patterns can be simple, such as the Miura-ori fold, or more complex, such as curved folds, which allow for more organic and fluid transitions between shapes [34]. Hidden within the folds of the origami rock sculpture are a series of nets and rubber hammocks which kids can enjoy. The play sculpture also has a metal slide. Computational models were developed to optimize these geometric structures, ensuring that they maintain structural integrity while offering flexibility and adaptability. This has been particularly useful when designing structures that need to be both light and strong, such as large-scale folding canopies or seating areas that can be expanded or compressed as needed [35]. In addition, the use of the geometric mosaic technique allows designers to create surfaces that not only provide play opportunities, but also stimulate children's visual and spatial cognition [36].

- *The pixel method of creating playground elements.*The design of the "Free Island" project is based on the concept of creating a "pixel game space" thanks to the work of the D+H laboratory (fig.A.2.3.15.).

✦ Landscape architects form the overall composition of the space as a complete and rich territory with various pixel components, which is the only landscape structure of the given area. The project is based on a pixel grid system, which not only provides flexible use of space, but also creates a positive atmosphere in the surrounding environment. In the northwestern corner of the grid is the Tetris area, with an area of 6,000 square meters. m. Despite the fact that Tetris Square is located in front of a commercial square, it is designed as a park connecting neighboring communities. On both sides of the square corridor, there are

playgrounds for children of different ages. According to the project authors' concept, the playground has several zones: Family Pocket is a place where children and parents can rest thanks to the presence of hammocks; "Free Island" is a three-dimensional playground for children, where they can physically explore space and exercise their bodies; other equipment design elements, such as Cloud Curtain, Cloud Mount and Cloud Pavilion, give children and their parents more opportunities to choose play activities. The combination of a series of spaces with all the various programs forms a mini-play park that serves the surrounding community. It is worth noting that compared to a traditional commercial square, the Tetris Square playground with a playground also has a landscape component and a large number of trees. Landscape architects "hide" this grove, integrating it into the game complex. Thus, this approach does not correspond to the traditional principle of forming the design of a commercial area, which consists in planting as few trees as possible to optimize the perception of shop windows. However, the strategy of the authors of the project is very successful, as it allows people in the area of the shopping center to remain in the shade of trees, which is especially important for the tropical and humid climate of this area. The overall composition of the play space is built on the basis of the use of two basic precast concrete modules, which can be combined and assembled in more than twenty different combinations thanks to the use of the combinatorial modeling method. Users of any age (adults and children) can, on their own initiative, offer the most convenient combination of furniture according to their needs. In addition to precast concrete furniture, the landscape architects also chose precast concrete pavers to pave the site. This decision was driven by environmental considerations, as natural stone is over-exploited in China. The shape of the circle was chosen by the designers as a universal symbolic form of unity, inclusiveness, integrity and perfection. This implies the idea of cyclic motion as perpetual motion. In order to create a more expressive composition of the game space, the main round shape of the game element was bent, which helped to create different functional profiles of the game equipment, resembling a solid ribbon.

The next example of a playground, PIXELAND is a project that includes a combination of different outdoor objects in one space, such as a landscape, a playscape for children and leisure for adults (illus.A.2.3.16.). The project is inspired by the concept of building game elements based on pixels. Transferring this idea to the strategy of spatial organization of the playground, the authors of the project create a multifunctional public space by adding and combining smaller independent functional pixels. It is worth noting that although each of the pixels has its own function and characteristics and can be perceived as an independent entity, the combination of all of them results in a very attractive and playful overall multifunctional public space. The main pixel used at the base of the game space is an ideal square of 5 x 5 m as the minimum space for placing functions suitable for a group of people, while as the boundaries are approached, smaller pixels of 2.5 x 2.5 m and 1 .25 x 1.25 m. This example demonstrates a modular approach to solving all functional zones, elements of pedestrian traffic and landscape on the border. It should be noted that each pixel is a component that performs different functions. Functional pixels are thus arranged in various combinations to create a hyper-stimulating hard geometric leisure landscape. Apart from the leisure opportunities, Pixeland also offers a wide range of play elements scattered around, culminating in a voxel themed horse play area in the middle of the square for the joy and fun of the little visitors. A voxel (from the English voxel — volume element) is a three-dimensional analogue of a pixel, which is an elementary volume in three-dimensional space used to construct three-dimensional images. The checkered square has been designed in a multi-level fashion, creating an interesting artificial topography that rises in height towards the center, where a voxelized horse is strategically placed on top.

- ***Parametric approach in playground design.*** This approach to using the Autodesk Inventor program allows you to simplify the development of game designs, speed up the analysis of the selected geometry for the creation of equipment and suggest its preliminary assessment using the production of prototypes. In the 1950s, witnessing the industrialization of the city, the

Guangzhou steel plant carried the memories of the hard times of its predecessors and left a special childhood for the "descendants of steel". As the special eras of the generation gradually disappeared and the places turned into industrial ruins, the plan for the future human settlement of the "new area of the Old City" slowly unfolded, and Guangzhou entered a new era of transformation of the old city (fig.A.2.3.17).

A clear example of a parametric approach in creating a children's playground is Playscape (fig.A.2.3.18). A playful network of large tubes containing walkways and bridges wraps around this children's community center in Beijing by local practice We Architech Anonymous (WAA), located in a series of renovated 1970s industrial buildings. Playscape, which has been shortlisted in the Dezeen Awards 2021 Landscape Design category, was designed for a children's healthcare facility specializing in research and play, and was created as a "sensory learning tool".

A cluster of former granaries forms the basis for the project, with a central courtyard transformed into an undulating landscape with steel frames, creating a series of new interactions between the existing buildings. "Beijing is a city where many children do not have access to adequate outdoor space within their immediate vicinity," the WAA said. "Kids are often drawn to risk, creating a feedback loop of design improvement and safety concerns...we allowed for a controlled element of risk where kids can learn to be more confident to solve problems on their own." Cut-outs revealing bright yellow play spaces, built-in trampolines and a series of mounds that can be scaled up to access the roofs of the original warehouses enliven this central landscape, which also acts to connect previously disjointed buildings on the site. Inside these former warehouses are a series of parametric playgrounds for children of all ages. These include crawl spaces and climbing areas with hanging fabrics, a suspended stretch net and classrooms for more focused learning, as well as a library and restaurant.

The following example inspires the naturalness of the materials used. Bamboo, as an ecologically clean material, dares to support the concept of

environmental protection and at the same time point to the possibility of using traditional technological processes in their new embodiment - based on a parametric approach (fig.A.2.3.19).

Earlier this year, Bamboo U and IBUKU launched the Bamboo Playground Design Competition, inviting architects and designers to submit innovative proposals for an eco-friendly and visually appealing playground for children built exclusively from bamboo. The aim of this competition was to explore the versatility of bamboo as a building material, demonstrating its potential as a sustainable, aesthetically pleasing and functional - to build sustainable playground design. Through an analysis of an innovative bamboo grid created with augmented reality by architects Christoph Krolla and Garvin Goepel in August 2023, we delve into the intricate world of parametric bamboo playground architecture, focusing on the application of plastic forms in dome structures through a series of detailed illustrations that reveal depth capabilities of this durable material.

Challenging contestants to redefine the limits of eco-friendly design in a world clamoring for sustainable solutions, the task for participants was to harness the strength, flexibility, and inherent beauty of bamboo to create a space where children can play, learn, and connect with nature. The Bamboo Playground should stand as a testament to the harmony achievable between the built environment and the natural world.

Conclusions to the second chapter

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CHAPTER III. PLAYGROUND DESIGN DEVELOPMENT BASED ON THE BIONIC APPROACH

Building on the findings from the literature review, case studies, and field observations, a design framework is developed that outlines the key principles and considerations for creating outdoor playgrounds. This framework includes guidelines for age-specific design, safety measures, material selection, and the integration of innovative design techniques such as fold-line design. The framework is structured to address the different growth needs of children across the 0-12 age range and to ensure that playgrounds not only engage children but also support their physical, cognitive, and social development.

The development of the design framework involves iterative testing and refinement. Preliminary design concepts are created based on the insights gathered from previous research stages, and these concepts are evaluated through expert consultation with professionals in child development and environmental design. Feedback from these experts is used to fine-tune the design framework, ensuring that it is both practical and effective in meeting the needs of children and the goals of the playground's educational and developmental objectives.

CONCEPT

Designing children's play spaces involves a thoughtful integration of safety, creativity, and developmental appropriateness to support children's physical, cognitive, emotional, and social development. A well-designed playground stimulates a child's imagination, encourages interaction and encourages exploration while maintaining a safe environment. Below are some basic principles that are taken into account when designing your own proposal for a children's playground.
1. ***Safety as the basis of design.*** Safety is the most important aspect when designing a space for children. Ensuring that the materials used in playgrounds are non-toxic, durable and hard-wearing is essential to prevent injuries. Age-appropriate equipment is therefore offered, with clear divisions between spaces designed for different age groups, to avoid accidents caused by physical or

developmental disabilities. To reduce the chance of injury from a fall, attention is paid to the development of shock-absorbing surfaces, such as rubber mats or sand. Safety also extends to the visibility of the playground, ensuring that adults can easily supervise children as they play. In addition, the design must meet international safety criteria and relevant standards, such as ASTM (American Society for Testing and Materials) or EN (European Standards).

2. Creativity and imagination in design. The proposed children's play space should promote creativity and give space for imagination. Designs that encourage children to interact with their environment, such as building with sand, playing in water, or interacting with plant life, can offer a variety of sensory-rich experiences that promote cognitive and creative development.

3. Appropriateness of development and age characteristics. Different age groups have different developmental needs, which are taken into account in the project proposal and reflected in the design of the playground. For example, toddlers (aged 0 to 3) are offered simple equipment focused on sensory exploration and motor development, such as low soft play structures. Preschool children (ages 3-6) benefit from equipment that promotes group play, social interaction, and gross motor skills, such as swings, small slides, or balancers. Older children (ages 6 to 12) need places that challenge their physical and social skills, with climbing structures, obstacle courses and spaces that encourage group collaboration. In the different functional areas, playground design is offered based on inclusivity to cater for children with different abilities, for example, including accessible ramps, sensory spaces and multi-functional equipment.

4. Encouragement to risk within safe limits. The project proposal includes play spaces that should provide children with the opportunity to test their limits in a controlled play environment. Risk and challenge are vital components of developing problem-solving skills, resilience and self-confidence. For example, climbing structures, obstacle courses and balance equipment allow children to take calculated risks, explore their physical limits and overcome fears. The challenge is

to provide this experience without exposing children to significant harm by ensuring that all equipment has appropriate drop heights and impact-absorbing surfaces. Here, a balance is taken into account between creating a stimulating environment that will promote physical and cognitive development, while maintaining a high level of safety for children.

5. Inclusiveness and accessibility in design. An important principle of designing children's play spaces is inclusiveness, which ensures that children of all abilities can participate in meaningful play. Universal design principles are taken into account in the creation of playgrounds, ensuring that elements such as ramps, wide paths and sensory elements are designed for children with physical, sensory or cognitive disabilities, as play spaces must be designed to offer different levels of engagement, from physical play (climbing, swinging) to sensory experience (touch, sound, color). Thus, creating an inclusive environment not only provides access, but also encourages social interaction between children with different abilities, fostering empathy and understanding from an early age.

6. Interactive and social games. As children learn to interact with others, play spaces should include elements that encourage shared play and communication, so interactive play panels such as puzzles or games that require more than one participant are offered to promote social interaction and collaboration. In addition, themed play areas can inspire creative play by allowing children to role-play and collaborate with peers in structured and unstructured scenarios.

7. Cognitive development through a strategic game. Game elements that require children to think critically, such as mazes, puzzles or structures with multiple paths and decision points, encourage them to use their cognitive skills. For example, elephant-like structures designed as adventure trails include vantage points that encourage children to assess their surroundings from an almost bird's-eye view. The equipment also has educational elements, such as scientific or mathematical panels, to further stimulate intellectual development.

8. Encouraging independent play and exploration. Play spaces with more secluded or private areas are offered, allowing children to engage in solitary play or reflection.

GENERAL CONCLUSIONS

This research provided an in-depth study of the design principles and strategies needed to create outdoor playgrounds that support the holistic development of children across age groups. Focusing on the developmental needs —physical, cognitive, emotional, and social—of children ages 0-12. The research highlights the importance of creating age-appropriate, inclusive and stimulating play environments. Insights from this research highlight that playgrounds are more than places to relax; they are a vital environment for fostering growth and learning.

1. The main results of this study emphasize the need for a balanced approach to the design of playgrounds, which carefully takes into account the specifics of the development of each age group. For infants and toddlers (0-3 years), the emphasis is on a sensory-rich environment that encourages early motor skills and sensory exploration. For preschool children (3-6 years old), playgrounds should promote social interaction, creative play, and the development of coordination. Older children (ages 6-12) benefit from an environment that challenges their physical abilities, encourages problem solving and encourages independent play.

2. It is proven that one of the main contributions of this research is the introduction of innovative design methods, such as bending lines, bionic and geometric designs, which increase the functionality, safety and aesthetic appeal of playgrounds.

3. It was determined that a linear approach in the design of playgrounds helps to create dynamic spatial configurations of equipment, which stimulates children's perception of space and promotes its exploration. A bionic approach to playground design, inspired by nature, creates an organic and engaging

environment that promotes creative play, a geometric approach ensures safety and spatial efficiency through the use of precise modular structures. The parametric approach, in turn, allows a new look at the modeling of children's playgrounds, taking into account both traditional materials in their development and traditional technologies specific to China. The integration of these methods of designing playgrounds allows creating diverse, attractive and safe play environments that contribute to the comprehensive development of children.

4. The important role of creating inclusive elements of gaming equipment, which plays a central role in this study, is determined. Playgrounds must accommodate children of all abilities, ensuring equal access to play opportunities. By incorporating universally accessible design elements such as ramps, ground-level play elements, and sensory equipment, playgrounds can accommodate children with physical, cognitive, and sensory differences. This commitment to inclusiveness promotes social inclusion, allowing children to interact with peers of different backgrounds and abilities, furthering emotional and social development.

5. The conceptual framework developed in this study brings together these diverse design strategies, demonstrating how interactions between bionic and geometric elements can assist in the creation of visually engaging, functionally efficient and developmentally appropriate playgrounds. The study also highlights the need for flexibility in playground design, allowing for the creation of modular and reconfigurable play areas that evolve according to children's needs and preferences.

6. In conclusion, this study has provided a comprehensive understanding of how outdoor playgrounds can be designed to holistically meet the developmental needs of children. By combining innovative design methods with a strong focus on inclusivity and diversity in playground design, we are able to design playgrounds that not only offer fun and recreation, but also serve as important environments for children's learning, growth and social engagement.

7. Future research and design efforts should continue to explore this area, in terms of how innovative materials technologies and new design methodologies can further enhance the play experience, ensuring that playgrounds remain important spaces for promoting healthy development of children in diverse urban environments, which are constantly changing.

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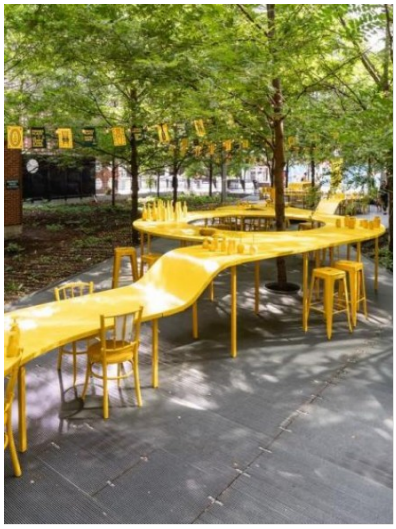
APPENDIX A



Figure. A.2.3.1. A complex approach in the design of a playground; Changzhou city; design: Bingxing Lin, Hao Lan, Jiahui Liang, Zhigang Liu, Qimei Ling, Zhihua Chen, Wanlu Ye, Wenxin Deng, Zheyi Yuan, Zhengzheng Xiong; 2018. https://ru.pinterest.com/pin/585960601507577141/







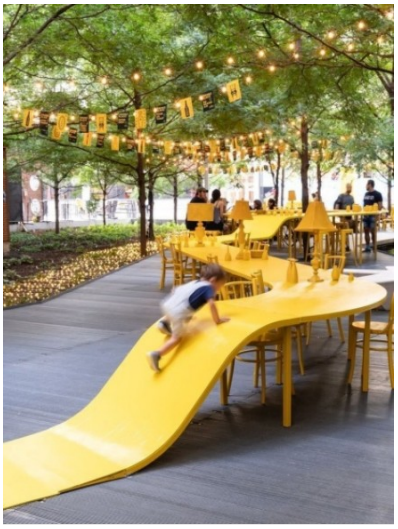


Figure.A.2.3.2. Linear approach (the adoption of curved form-making) in the design of the playground
https://playpoint.asia/insights/built-to-last/



Figure.A.2.3.3. Linear approach (acceptance of curved form formation) in the design of children's play space
https://100architects.com/project/blue-ribbon/



Figure.A.2.3.4. Linear approach (adoption of spiral shaping) in site design
https://playpoint.asia/insights/built-to-last/



Figure A.2.3.5. Bionic Design: Drawing Inspiration from Nature
https://image2.znzmo.com/1676814543332_4157.jpeg?x-oss-process=style/detail



Figure A.2.3.6. Bionic approach.

https://www.behance.net/gallery/44782017/JOY-Concept-Playground?playgroundideastoday=2076452802



Figure A.2.3.7. Bionic approach.

https://www.pinterest.com/pin/447123069255584789/



Figure A.2.3.8. Bionic approach.

https://i.pinimg.com/originals/8c/a3/42/8ca342001240ba1d07d07024c9cd5445.jpg

















































Figure A.2.3.9. Bionic approach. Daishan Donghai Country Park, 2022

https://mooool.com/en/donghai-cultural-discovery-park-by-antao-group.html



Figure A.2.3.10. Bionic approach. Daishan Donghai Country Park, 2022

https://mooool.com/en/donghai-cultural-discovery-park-by-antao-group.html



Figure A.2.3.11. Bionic approach. Daishan Donghai Country Park, 2022

https://mooool.com/en/donghai-cultural-discovery-park-by-antao-group.html



Figure A.2.3.12. Bionic approach.2020. https://mooool.com/sinic%C2%B7turn-cocoon-into-butterfly-outdoor-educational-paradise-by-mbdi.html













Figure A.2.3.13. Bionic approach, 2020. https://mooool.com/sinic%C2%B7turn-cocoon-into-butterfly-outdoor-educational-paradise-by-mbdi.html



Figure A.2.3.14. Jurong West's origami playground.
https://playpoint.asia/projects/public-residences/826-jurong-west-st-81/



Fig.A.2.3.15. Geometric approach in the design of the "Tetris Square" playground; Guangzhou, China; 2017 Designers: Huicheng Zhong, Feimin Song, Hao Lan, YoungJoon Choi, Shaozhong Yuan, Wanlu Ye, Liujun Deng, Bingru Xiao, Yongkai Shen

https://mooool.com/en/tetris-square-by-lab-dh.html





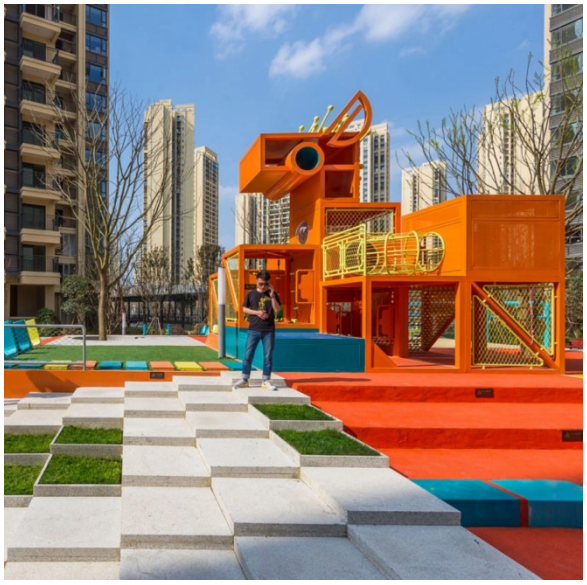


Fig.A.2.3.16. Playground PIXELAND.

https://100architects.com/project/pixeland/





Fig.A.2.3.17. Parametric design of the Grasshopper Playground. Designer: L&A Design. Location: Guangzhou, China.
https://www.linkedin.com/posts/parametric.architecture_publicspace-parks-park-activity-6919202061297270785-RrFb





Fig.A.2.3.18. Parametric Playground. We Architech Anonymous (WAA); Beijing

https://www.dezeen.com/2021/10/18/waa-playscape-childrens-community-centre-beijing/





Fig.A.2.3.19. Bamboo Playground Design Contest

https://www.archdaily.com/tag/bamboo

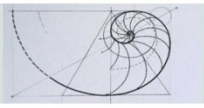
APPENDIX B

Basic approaches in deciding the design of children`s playground			
Folded	This approach is proposed as an idea of returning to the basics of the foundation through the folding-unfolding of terrain gets		1
Linear	This approach is suitable for users of all ages and levels of physical and mental development, provides a safe but challenging gaming environment that encourages children of all ages to experiment while playing		2
Bionic	This approach the design of systems and structures inspired by nature has proven to be very effective in the context of play space		3
Geometric	This approach has always played an important role in architectural design, its application in the design of the game space acquired a new dimension with the advent of computational design tools	 	4
Parametric	This approach, when using the Autodesk Inventor program, simplifies the development of game structures, accelerates the analysis of the selected geometry and allows you to conduct a preliminary assessment of the design thanks to the created prototypes		5

Tabl.B.2.3.1. Basic approaches in deciding the design of children's playgrounds

FOLD-LINE DESIGN			
Design Inspiration and Concept	Fold-line design draws inspiration from architectural and urban planning theories, utilizing the concept of folding and unfolding terrain gaps to create dynamic, flexible, and captivating play spaces.		1
Spatial Perception and Exploration	By developing continuously angled lines or "folds," fold-line design creates spatial configurations that differ from traditional straight or curved structures, enhancing children's spatial perception of the environment and promoting their exploration of it.		2
Integration with the Environment	Fold-line design emphasizes integration with the surrounding environment, skillfully utilizing terrain and existing landscape elements to create play spaces that coexist harmoniously with the natural setting.		3
Support for Children's Development	Fold-line design supports children's physical, cognitive, emotional, and social development by providing diverse play environments and challenges. It encourages free exploration and creative play, fostering their imagination and innovation capabilities.		4
Innovation and Sustainability	Fold-line design embodies innovation, bringing new ideas to children's playground design through novel spatial organizations and material applications. At the same time, it may also consider sustainability, such as using renewable materials or designing play facilities that are easy to maintain and upgrade.		5

Tabl.B.2.3.2. FOLD-LINE DESIGN

LINEAR DESIGN			
Design Principles and Theoretical Support	Linear design employs forms such as straight lines, spirals, or curves for spatial layout, with design principles based on the optimization of spatial organization and pedestrian flow. It aims to guide children's play paths and interaction patterns through linear structures.		1
Age Adaptability and Personalized Design	Linear design can cater to the needs of children of different age groups by adjusting the complexity and challenge level of the linear elements, providing personalized gaming experiences for children.		2
Spatial Layout and Fluidity	Linear design emphasizes the fluidity of spatial layout and the rationality of pedestrian flow, connecting various play areas through continuous linear elements to promote free movement and exploration within the play space.		3
Visual Effects and Attractiveness	Linear design can create eye-catching visual effects through unique lines and shapes, enhancing the attractiveness and fun of the play space.		4
Safety and Functionality	While focusing on aesthetics and fun, linear design also fully considers safety and functionality. Through reasonable structural design and material selection, it ensures the safety and durability of the play facilities, while meeting children's play needs.		5

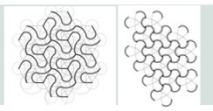
Tabl.B.2.3.3. LINEAR DESIGN

BIONIC DESIGN			
Drawing Inspiration from Nature	The design inspiration originates from the natural world, where the forms, structures, and functions of living organisms are mimicked to design playground facilities.		1
Application of Bionic Design in Playgrounds	Imitating natural forms such as trees, rocks, animals, and others to design play equipment, and how these facilities contribute to children's development.		2
Unity of Functionality and Aesthetics	Bionic design not only focuses on the functionality of the facilities but also pursues an aesthetically pleasing appearance to attract children and enhance the overall environment of the playground.		3
Ecological Education Significance	By interacting with and learning about the natural elements in bionic design, children can enhance their understanding and awareness of the natural environment, fostering a sense of protection.		4
Sustainability and Environmental Friendliness	Bionic design has advantages in terms of sustainability and environmental friendliness. This includes the use of eco-friendly materials, energy-saving technologies, and the preservation of biodiversity, among other aspects.		5

Tabl.B.2.3.4. BIONIC DESIGN

GEOMETRIC DESIGN			
Design Theory and Principles	Geometric design is based on the principles and methods of geometry, utilizing precise shapes, lines, and proportions to create spaces that exude a sense of order and aesthetic beauty. In playground design, geometric design theory emphasizes the use of geometric shapes to organize space, providing an orderly yet varied gaming environment.		1
Modularity and Flexibility	Geometric design often adopts a modular approach, where standardized geometric units are combined to form diversified play equipment. This modular design not only enhances construction efficiency and flexibility but also allows playground facilities to be adjusted and expanded as needed.		2
Spatial Organization and Directionality	Geometric design guides children's play paths and visual directions through precise geometric shapes and spatial layouts. For example, by combining straight lines, curves, and circles, directed play spaces can be created, encouraging children to explore and interact across different areas.		3
Visual Impact and Attractiveness	Geometric design, with its unique shapes and color combinations, creates a strong visual impact, capturing children's attention. The inspiration from origami art mentioned in the paper utilizes complex geometric folding structures to create a visually appealing and challenging gaming environment.		4
Technological Innovation and Application	The application of geometric design in playgrounds continues to introduce new technological innovations. For instance, the use of computer-aided design tools enables designers to more accurately simulate and optimize geometric shapes and spatial layouts. Furthermore, new materials and technologies offer additional possibilities for the realization of geometric design.		5

Tabl.B.2.3.5. GEOMETRIC DESIGN

PARAMETRIC DESIGN			
Design Process and Methods	Utilizing parametric software for model construction, generating multiple design schemes through parameter adjustments, and achieving optimal design results through iterative optimization.		1
Technological Advantages and Innovation	Parametric design offers technological advantages in enhancing design efficiency, realizing complex forms, and increasing design flexibility.		2
User Experience and Interactivity	Parametric design can create more attractive and interactive play spaces, stimulating children's curiosity and desire for exploration through dynamically changing design elements, thereby enhancing the user experience.		3
Challenges and Future Prospects	Challenges faced by parametric design in children's playground design, including technical barriers, cost issues, and designers' adaptability.		4

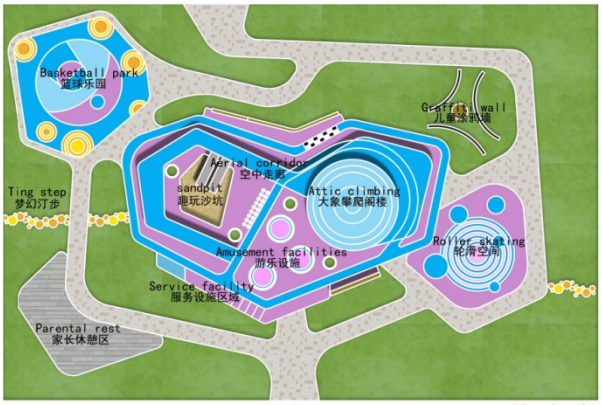
Tabl.B.2.3.6. PARAMETRIC DESIGN

APPENDIX C



1 living quarters
2 school
3 plaza
4 forest

Area chart



Plan drawing









Instructions

The project is located on land to be developed in the center of the city. The surrounding area is dominated by residential areas and lacks landscape support. There is also a primary school nearby, which provides education for the surrounding residents. In addition, there is a square next to this area, but unfortunately, there is no place for children to play. But this area has the advantage of being surrounded by large forests.

Here we plan an open-air, unpowered children's playground with a plot size of 60 m x 40 m. Provide a space for young children to learn, play and grow.

In this context, we will consider the study of children's playgrounds, including the study of design form and the study of function.








萌仔乐园













