Family Parent-Child Woodworking: An Experimental Study on Children Making Luban Locks

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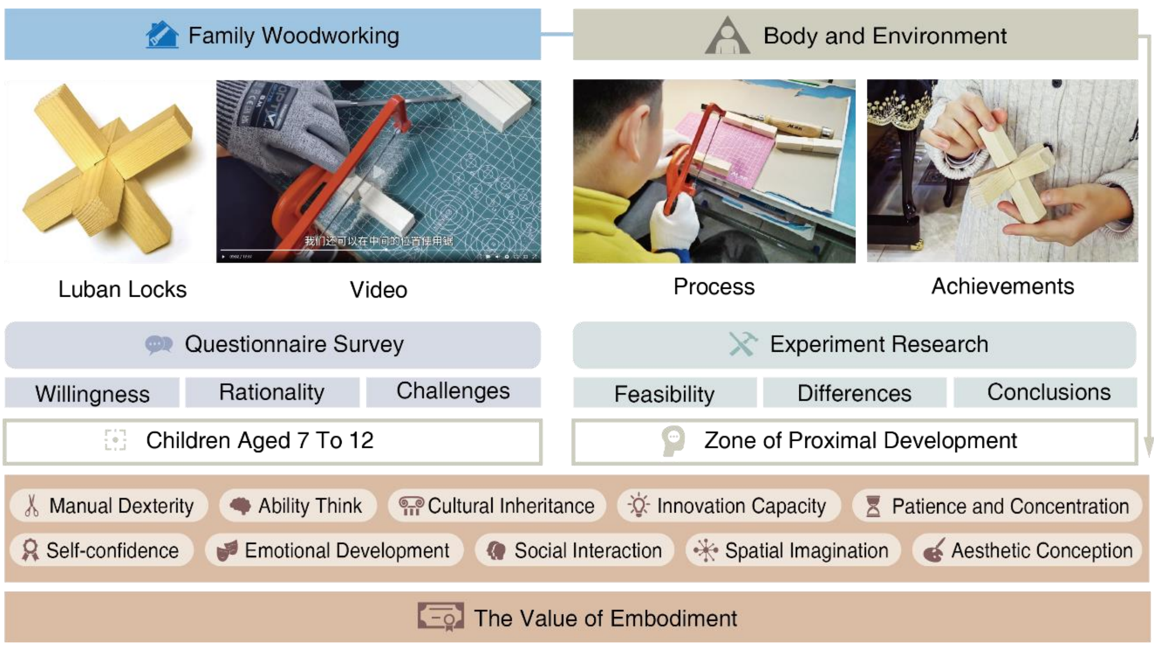
GRAPHICAL ABSTRACT



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This study examined the feasibility and benefits of children completing woodworking projects at home in Chinese families, using online video tutorials and parental guidance. A survey assessed family interest and gathered background information, selecting 36 Chinese families with children aged 7 to 12 for an experiment on making traditional Luban locks. The projects were divided into two levels: a basic, video-assisted three-post lock completed by children with parental help; and an advanced, six-post lock, requiring families to find resources independently. Results indicate that the majority of families showed strong interest in parent-child woodworking (76.7%) and successfully completed the basic project (94.4%). However, only a small minority managed to complete the advanced project (8.3%). The study indicates that while children aged 7 to 12 are in a concrete operational stage of cognitive development, success in these projects isn't solely age-dependent. Parent-child woodworking in Chinese families appears feasible and beneficial for cognitive growth when projects are age-appropriate. Findings suggest designing tasks within a child's zone of proximal development with corresponding resources, offering insights for family-based learning approaches.

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Keywords: Family woodworking; Children's cognitive development; Luban lock making; Parent-child collaboration; Experimental study

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INTRODUCTION

Since the dawn of humanity, people have relied on wood for survival. In primitive societies, wood was essential for hunting with spears, making fire, and building shelter. With the rise of agrarian societies, wooden tools became vital for farming, constructing homes, and creating furniture (Perlin 2005). Even today, wood remains widely used in architecture, furniture, crafts, and toys, contributing significantly to the development of human civilization. In ancient times, woodworking was considered an essential life skill, and many children picked up basic woodworking techniques by observing adults, making simple toys like wooden puppets, swords, spinning tops, and wheeled carts with the help of family members. This process helped them develop various skills and supported well-rounded growth. However, as technology advanced and specialization increased, woodworking became less common. Most people no longer engage in it, and children have fewer opportunities to experience woodworking firsthand, despite its recognized value in enhancing practical skills, embodied cognition, and STEM education. Even among adults, few pursue woodworking as a hobby, often opting for various other types of crafts instead.

Studies show that woodworking's inherent risks and environmental demands have contributed to its decline, but there is limited research providing concrete evidence or in-depth experimental studies on this topic.

For years, the global fertility rate continues to decline, leading to a steady decrease in the proportion of children within the population (United Nations 2022). This trend is especially pronounced in China, where low birth rates have heightened parental focus on child education. Toys and play have become essential components in children's lives, supporting the development of cognitive, motor, social-emotional, and language skills, while also fostering self-confidence, creativity, and positive emotional well-being (Cankaya *et al.* 2023; Fan *et al.* 2024). Moreover, toys help parents and other caregivers to form close connections with children (Healey *et al.* 2019; Dag *et al.* 2021).

Wooden toys, revered for their natural composition and educational value, remain a significant choice in the children's toy market due to their safety, cultural significance, and environmental sustainability. A prominent theme in these documents is the safety of wooden toys and their potential health risks to children. These toys not only provide a non-toxic play experience but also foster cognitive development and traditional values, aligning with the preferences of health-conscious consumers (Z. Wang *et al.* 2021). The research covers harmful substances that might be present in the materials of wooden toys, such as the migration and exposure risks of heavy metals such as lead. These studies underscore the importance of regulation and quality control for the safety of wooden toys to protect children from harmful substances (Bank and Carolan 1993; Abdelazeem *et al.* 2021). Some studies focus on the innovation and smart technology of wooden toys. With technological advancements, researchers are exploring how to combine traditional wooden toys with modern technology to create new educational and entertainment tools (Fu and Chen 2021). For example, there are studies introducing a digital wooden tabletop maze for assessing children's cognitive abilities (Christopher *et al.* 2019). There is also research proposing the concept of "grasping algorithms" to teach computational thinking through wooden toys (Root *et al.* 2017). These studies demonstrate the potential of wooden toys to adapt to modern educational needs and technological progress.

Wooden toys have long been a staple in children's playrooms, but their true educational potential extends beyond mere play. These toys are celebrated for their capacity to foster cognitive development, especially when it comes to nurturing computational thinking skills through the design of smart wooden toys. Moreover, research has delved into the evolving preferences for wooden toys within the realm of children's imaginative play, shedding light on how these choices map onto their psychological growth. This body of work underscores the profound educational impact of wooden toys on a child's cognitive and emotional landscape (Cai and ACM 2023).

Building on this foundation, there's a burgeoning interest in the educational benefits of not just engaging with wooden toys, but in the act of crafting them as well. Despite the ubiquity of wooden toys in children's lives, many kids remain uninformed about the process behind their creation, thus forfeiting the enriching experience of making toys with their own hands. This gap poses an intriguing question: Is it possible to inspire children to take up woodworking and create their own toys? The field of pediatric woodworking is relatively uncharted, with scant research exploring its potential. In our study, a pioneering study is now venturing into this territory, investigating the viability of woodworking as a family bonding activity. By conducting an experiment where families collaborate to craft toys using video tutorials, the study seeks to assess the feasibility and challenges of home-based family woodworking. This initiative not only amplifies the educational benefits of wooden toys but also exposes children to the art of craftsmanship, potentially intensifying their connection to and comprehension of the toys they cherish.

By addressing these challenges, the study also hopes to shed light on how family woodworking impacts children's hands-on skills, embodied cognition, and engagement in Science, Technology, Engineering, and Mathematics (STEM) education, thereby offering insights for enhancing family educational practices. The contribution of this paper includes the following two aspects:

(1) Feasibility of family woodworking projects with children in China: Research children's interest in participating in family woodworking projects. Design a series of experiments to assess whether age-appropriate children can successfully complete woodworking projects at home with the help of online instructional videos. Also, identify any challenges that arise during these activities and investigate their underlying causes.

(2) Value and significance of family woodworking projects: Explore the specific educational and relational benefits that family woodworking projects offer to children and parent-child relationships. Also, examine the development trends of this activity.

LITERATURE REVIEW

Parent-Child Woodwork Games

Family woodworking, where children work together with parents on woodworking tasks, is a valuable, high-engagement form of parent-child play. Parent-child games have been widely shown to foster cognitive, emotional, and social development in children. However, various factors have contributed to a decline in the amount of quality parent-child playtime, which can negatively impact children's developmental gains from play. More research is needed to explore how to balance children's play and academic needs, and to create positive, child-centered play environments that promote social, emotional, cognitive, and environmental growth (Ginsburg 2007). Children's use of electronic toys can reduce the quality and quantity of parent-child verbal interactions, while traditional toys enhance parent-child playtime (Sosa 2016). Playing together for 15 to 45 min strengthens parent-child relationships, makes children more confident, and cultivates a positive, fearless attitude (Chang and Yeh 2015). Luo's research on the interactions between toys, environment, and children's exploratory behaviors indicates that children's exploratory behaviors are influenced by their surroundings and are more readily activated in the presence of peers (Luo and Chen 2010). Parent-child games require suitable toys, project types, and tools, as well as well-designed play strategies. Age-appropriate toys are better utilized by children, who can also benefit from playing with higher-age toys under guided supervision, albeit with necessary restrictions based on toy type (Richards *et al.* 2022). Studies suggest that guided play is more effective than direct teaching or free play in presenting educational goals and scaffolding the play environment, which enhances children's motivation and engagement (Weisberg *et al.* 2013). Song *et al.* (2020) developed a system combining mixed-reality technology with handicraft and storytelling, finding that it effectively increased children's interest and improved parent-child relationships.

Embodied Cognition

Embodied cognition theory posits that cognition does not occur solely in the brain but rather involves an organic interaction with the body (Foglia and Wilson 2013). From this perspective, physical activity during play contributes to multiple dimensions of cognitive development in children (Chandler and Tricot 2015). Piaget (1931) argued that cognitive development in children arises from sensorimotor interactions with the world. Cognition occurs through the body and requires environmental engagement. Context, bodily perception, and motor systems are key to forming embodied cognition. In family woodworking activities, children employ imagination and creativity through physical movement, thereby shaping and deepening their cognitive understanding. This process encompasses sensory perception of materials, knowledge and operation of tools, understanding of shapes and structures, and envisioning and realization of functional designs. It involves cognitive, motor, and emotional experiences, representing an intricate interaction between body and mind.

Spatial Skills and STEM Competencies

Different types of play activities enhance specific skills, and woodworking play can support children's development of spatial skills and STEM competencies. Spatial thinking is essential to cognition, underpinning learning and everyday activities, and significantly predicting children's success in STEM. Family woodworking activities, involving hands-on exploration, visual cues, and gestural spatial training, can effectively foster spatial skills. Researchers advocate developing high-quality, evidence-based, and environment-appropriate spatial training programs for children (W. Yang *et al.* 2020). Borriello and Liben (2018) encourages parents to guide preschoolers' spatial thinking through block play, helping to build spatial cognition skills. Verdine *et al.* (2014) shows that preschool children's spatial skills in block play correlate with early math skills. Further studies demonstrate that spatial training activities can significantly improve children's math skills, aiding number knowledge acquisition through spatial representation (Gunderson *et al.* 2012; Cheng and Mix 2014). Experiments with educational robots and low-cost self-made toys confirm that project-based learning can foster STEM knowledge and skills in elementary students, with learning outcomes positively correlated with students' attitudes toward learning (Hu *et al.* 2024). Additionally, parental expectations for STEM education vary by child's gender, which can influence educational directions (Zhan *et al.* 2023).

Wooden Toys and Woodworking

Some scholars have noted that "play is children's only work" (Dag *et al.* 2021). Today, toys are diverse in material and form, yet wooden toys remain a mainstay of children's playthings. Studies on wooden toys are abundant, and safety is a significant aspect. Children's age, cognitive levels, and physical conditions limit the woodworking tasks they can safely manage and require heightened attention to safety risks. Studies highlight the importance of toy safety, prioritizing factors such as the absence of small parts, non-toxic preservatives and paints, craftsmanship quality, and contributions to physical and cognitive development (Singer and Özşahin 2023). In a study on woodworking injuries in France, Loisel *et al.* (2014) reveals that most injuries are hand-related and stem from lack of protective equipment, underscoring the importance of equipment maintenance, safety education, and proper safety gear use. Besides tool-related risks, considerations include the hazards posed by certain woods, surface treatments, and work environments. Z. Wang *et al.* (2021) assess the risks associated with preservatives in wooden toys. Extended exposure to wood dust may lead to respiratory or skin diseases (Kauppinen *et al.* 2006), all of which must be prioritized and assessed in woodworking activities. Some studies integrated traditional wooden toys and modern educational technology to enhance play function. Singer and Özşahin's (2023) study on decision weight distribution for wooden toy design shows that wood's texture, color, feel, weight, and scent influence children's sensory and play experiences. Investigating children's preferences for wooden toys promotes the efficient use and matching of toy materials (Liu and Lee 2023). Wang's study on embedded sensors in toy blocks reveals that playing with blocks can highlight children's behavioral issues (X. Wang *et al.* 2021). Fu and Chen (2021) redesigned traditional Chinese wooden toys from an embodied cognition perspective adapts them for modern society, enhancing children's hands-on abilities, mental development, and cultural cognition. Work on constructive toy design in the context of traditional crafts shows that these toys improve children's creativity and craftsmanship skills (Yang 2019). Furthermore, the "modular" nature of constructive toys fosters children's inventive thinking and abilities (Yang 2017).

EXPERIMENTAL

Research Design

This review indicates that the value of wooden toys has been well-established. However, allowing children to make wooden toys independently raises additional concerns. To test the feasibility of family woodworking, the study design included projects of varying difficulty levels to identify children's adaptability within a given developmental stage and draw more accurate conclusions. As is shown in Fig.1, the chosen woodworking project was the Luban lock, a traditional Chinese interlocking puzzle toy with over 2,000 years of history, known for its variety and complexity.

Fig. 1. The Luban lock for kids

The Luban lock involves fitting wooden pieces together, requiring a high degree of coordination and cognitive development, which makes it suitable for evaluating children's spatial and cognitive abilities (Li *et al.* 2022). Two versions of the lock were used for this study: a simpler three-piece lock and a more complex six-piece version. This progression in difficulty was intended to help evaluate the feasibility and value of family woodworking. Based on literature review and relevant market research, the experiment was designed to address issues related to age and skill compatibility, materials, safety, activity setting, and data collection.

Before the research, an instructional video was produced for the three-piece Luban lock, including a cultural introduction, step-by-step instructions, safety precautions, and a demonstration of how to play with the completed lock, as shown in Fig. 2.

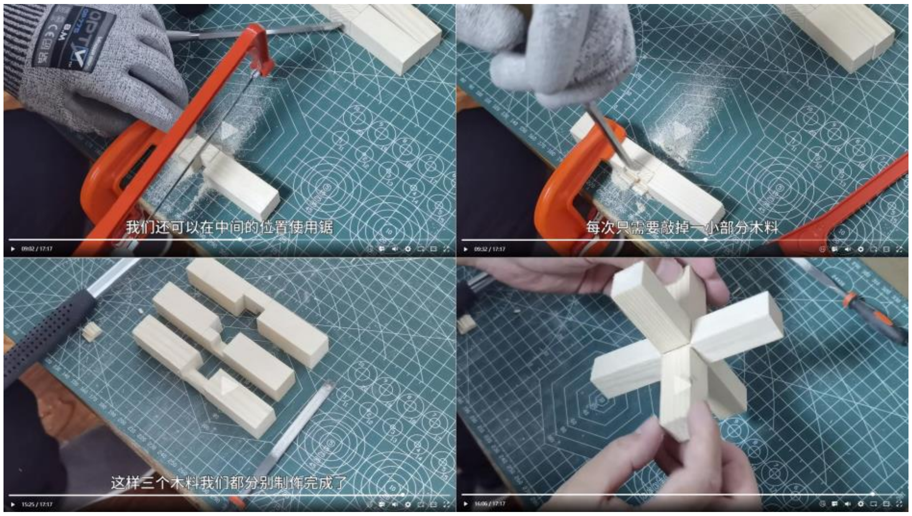

Fig. 2. Tutorial video of how to play with the completed Luban Lock

To fulfill the significance and objectives of this study, a questionnaire survey was followed by an experimental investigation (Fig. 3). Both stages played crucial roles in shaping the research findings and ensuring the rigor and validity of the study.

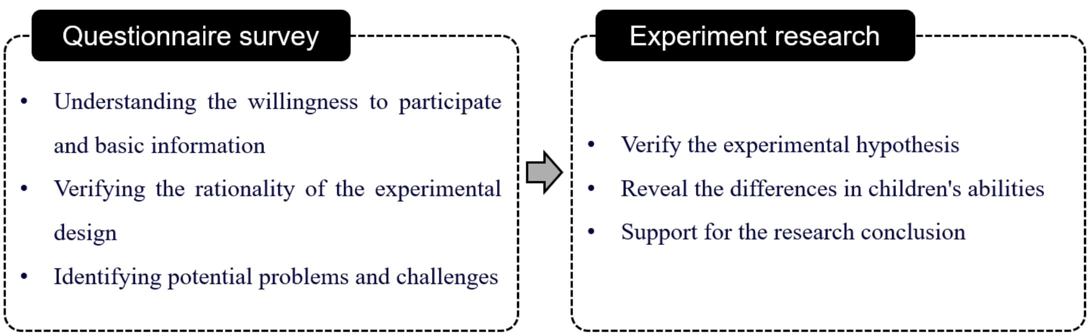

Fig. 3. Research stages of this paper

The Questionnaire Survey Stage: A Foundation for Understanding and Design

The questionnaire survey served as an initial step to gather essential information and insights. It allowed the investigators to understand the basic demographics and preferences of the potential participants, including children's ages, toy preferences, practical skills, and their willingness to engage in family woodworking activities. This information was pivotal in selecting an appropriate and representative sample for the subsequent experimental phase.

The Experimental Research Stage: The Feasibility of Family Woodworking and its Impact on Child Development

The experiment aims to explore the feasibility, practicality, and potential impact of family parent-child woodworking activities. It seeks to assess whether these activities can engage both children and parents, examine children's performance and the factors influencing it, and evaluate the activities' potential to promote children's cognitive development. Ultimately, the goal is to provide new insights and empirical foundations for family education and related research, offering a novel and effective approach to enhancing parent-child interaction and cognitive growth.

The Questionnaire Survey Stage

Children aged 7 to 12 are in the concrete operational stage, with basic logical reasoning, spatial imagination, and simple arithmetic skills, all of which are compatible with the skills required to build a Luban lock. Based on the theory, the survey was conducted using an online questionnaire. Targeting families across the nation, with the aim of gaining a comprehensive understanding of children's preferences for toys as well as families' attitudes towards and participation in woodworking activities. The questionnaire encompassed various aspects, including participants' demographic information, types of toys currently owned, assessment of children's hands-on skills, families' level of interest in woodworking activities, and their perception of the educational value of such activities. Through the extensive collection of data, a solid foundation was established for the subsequent selection of participants for the experiment. As shown in Fig. 3, a total of 227 valid responses were collected, and the results that a Luban lock project would be warmly received by families.

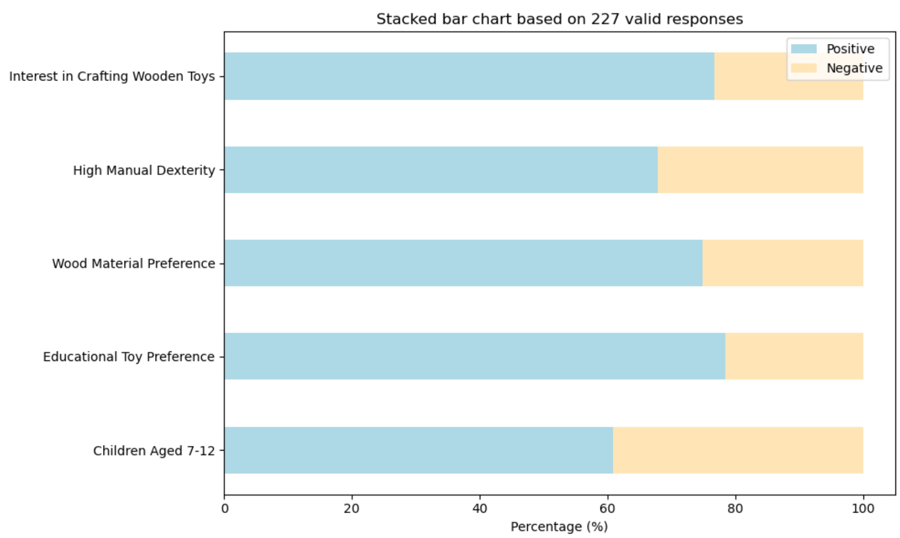

Fig. 4. Survey on children's toy preferences and educational attitudes

The study presents a detailed analysis of children's preferences and parental attitudes toward woodworking and educational toys, based on a representative sample of 36 families from 13 provinces in China, comprising 21 boys and 15 girls. Notably, 60.8% of the surveyed children fell within the age range of 7 to 12, indicating a significant cohort interested in hands-on activities.

Regarding toy preferences, the results revealed that 78.4% of children exhibited a preference for educational toys, while 74.9% favored wooden toys. This underscores a strong inclination toward both educational and traditional materials in play. Furthermore, 67.8% of parents rated their children's hands-on skills as good, reflecting a positive assessment of their children's potential in woodworking and crafting activities.

Of particular interest, 76.7% of children expressed a keen interest in crafting wooden toys with their parents under the guidance of instructional videos, highlighting a desire for interactive and educational experiences. When considering potential safety hazards associated with woodworking, families demonstrated a balanced approach.

Specifically, 51.5% of families expressed willingness to participate with appropriate safety measures in place, while 41.0% indicated they would make decisions based on the specific situation.

Safety and children's interest emerged as primary concerns for families engaging in woodworking activities. Notably, 90.7% of parents acknowledged the educational value of woodworking for children, further supporting the idea that such activities can be both enjoyable and beneficial.

Moreover, the survey results provided valuable feedback on the rationality of the experimental design. Most parents and children expressed a positive attitude towards family woodworking, which not only reinforced the feasibility of the proposed study but also enhanced the overall practicality of conducting the experiment. This preliminary validation was critical in ensuring that the research design aligned with the expectations and interests of the target population.

Additionally, the questionnaire survey helped identify potential challenges and concerns associated with woodworking activities, such as safety issues and production difficulty. These insights were instrumental in developing strategies to address these concerns during the experimental phase, thereby minimizing potential obstacles and ensuring a smoother research process.

The Experimental Research Stage

The woodworking experiment conducted within the familial context garnered enthusiastic participation, as evidenced by the keen interest demonstrated by the 36 carefully selected families, each comprising children aged between 7 and 12 years. Each family was provided with the materials and tools for making Luban locks, along with a detailed observation form to guide parents and children through the process. The three-piece Luban Lock kit came with precision laser-etched guidelines, while the six-piece version only included the raw materials, as is shown in Fig. 5. Moreover, two additional pieces were prepared to guard against fabrication errors during the experiment.

Fig. 5. The materials and tools required to make a Luban lock

Each family was instructed to follow these steps:

- Step 1: Parents introduced children to the overall experiment, recording the children's emotional responses to each step.
- Step 2: Families completed safety training, introduced children to materials and tools, and followed the instructional video to make the three-piece Luban lock.
- Step 3: Children self-assessed their performance.
- Step 4: Families recorded their attempts to build the six-piece Luban lock.
- Step 5: Children shared their feelings and the objective factors affecting the family woodworking experience.
- Step 6: Parents provided subjective feedback, including an experiment summary, children's performance, and suggestions.

Upon project completion, parents were prompted to submit photographs documenting the process, accompanied by the corresponding observation forms. The research team systematically gathered all 36 observation forms and associated data, as is illustrated in Fig. 6.

Fig. 6. Process and product photos of Luban lock craft

RESULTS AND DISCUSSION

The questionnaire survey and experimental data played complementary roles in achieving the significance and objectives of this study. The survey provided the necessary foundation for understanding the participant pool and validating the research design, while the experimental data offered empirical support for the research hypotheses and conclusions. Together, they contributed to a comprehensive and rigorous investigation of the feasibility and benefits of family parent-child woodworking activities.

After completing the experimental observation record form and collecting all relevant materials, the data were aggregated and processed. The following analysis is structured around six sections of the experimental record form.

(1) Children's emotional feedback during the preparation step

The emotional feedback information is shown in Fig.7.

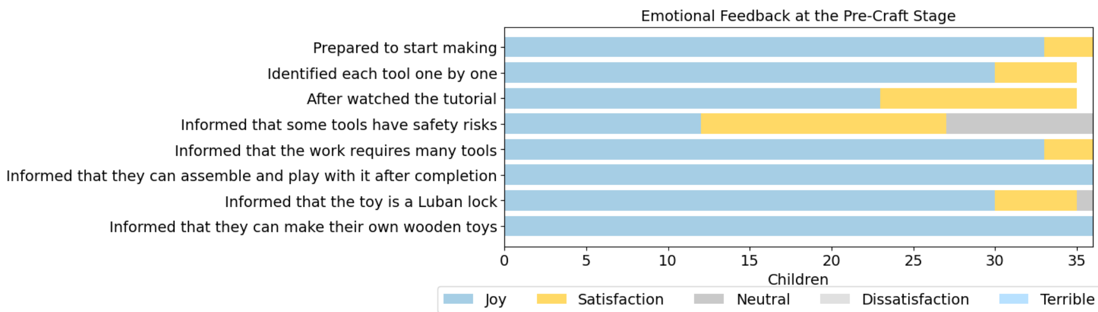

Fig. 7. Children's emotional feedback at the pre-craft stage

Embodied cognition emphasizes the unity of knowledge, emotion, and will, where emotions and participation during the cognitive process are considered significant influences on the cognitive outcomes of physical activities. According to the scale results, most participating children exhibited joy and satisfaction upon receiving the material packages and understanding the creation content and demonstrated a high level of interest in the subsequent creation process. This overall positive emotional state ensures the authenticity of experimental feedback. Additionally, it was observed that some children had concerns about the safety risks associated with the tools, indicating that the participating children possessed a good awareness of risk.

(2) Documenting the process of constructing a Luban lock

The process of constructing a three-pillar Luban lock was systematically divided into 16 distinct steps, as outlined in the provided recording sheet. Parents were tasked with assisting in recording several key metrics for each step, including the time taken, level of completion, reasons for failure (if applicable), and a self-assessment of quality by the child. The level of completion was categorized into four distinct classifications: Easily completed (Easy) / Normally completed (Normal) / Completed independently with difficulty (Hard) / Unable to complete independently or completed with parental assistance (Unable). There are totally 16 construction steps which are shown in Fig. 8.

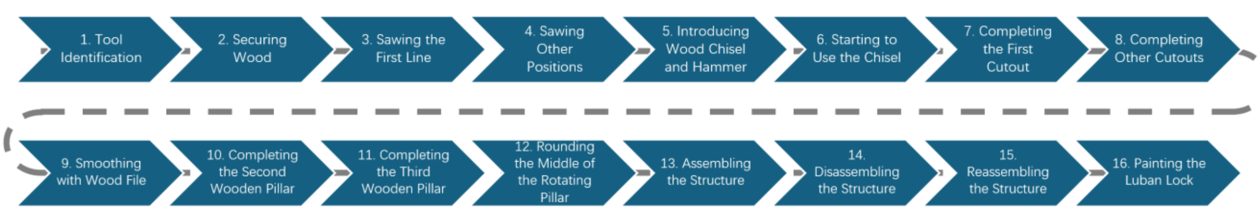

Fig. 8. Construction steps

In cases of failure, the underlying reason was further classified as either a production error or an excessive level of difficulty. The detailed performance data for participating children is presented in Tab. 1, In the section challenge failure and reason, the categories include Making Errors and Too High Difficulty. Analysis of the data indicates that two participants abandoned the task midway, while the majority (94.4%) successfully completed the experimental challenge. The self-assessed quality scores were generally high. However, substantial variability was observed in total time taken and task performance, leading to significant differences in self-assessed quality scores.

Table 1. The Process Data of Making Three-Pillar Luban Locks

Family No.	Age	Total Time (min)	Easy	Normal	Hard	Unable	Making Errors	High Difficulty	Quality Self-Evaluation Score
1	7	64	3	6	3	4	0	0	75
2	8	180	1	6	8	1	0	0	79
3	12	130	12	4	0	0	0	0	95
4	9	90	4	3	5	4	1	3	57.5
5	8	Not Completed	2	2	0	0	2	1	13.5
6	9	158	4	2	3	4	1	3	54
7	9	57	7	4	1	4	1	2	56
8	10	68.5	4	2	5	5	0	1	58
…									
36	11	84	9	4	3	0	0	0	79.5
Ave.	9.6	97.4	5.3	4.1	4.4	2.2	0.2	0.6	79.5

Children aged 11 to 12 demonstrated the best overall performance, while those aged 7 to 10 exhibited greater variability. Interestingly, performance in this younger group did not correlate proportionally with age, as the relationship between age and performance displayed a non-normal distribution. Children aged 7 to 8 required more frequent parental intervention compared to older participants.

The primary challenges were concentrated in three specific stages of the process:

- Cutting the first cylinder's notch using a woodworking chisel (Steps 6 to 8).
- Shaping the cylinder using a woodworking file (Step 12).
- The initial assembly of the completed components (Step 13).

Parental assistance was notably higher in these stages, with intervention frequencies of 33.3% for Step 6 to Step 8, 47.1% for Step 12, and 26.5% for Step 13. In contrast, parental intervention in other stages remained below 20% , as is shown in Fig. 9.

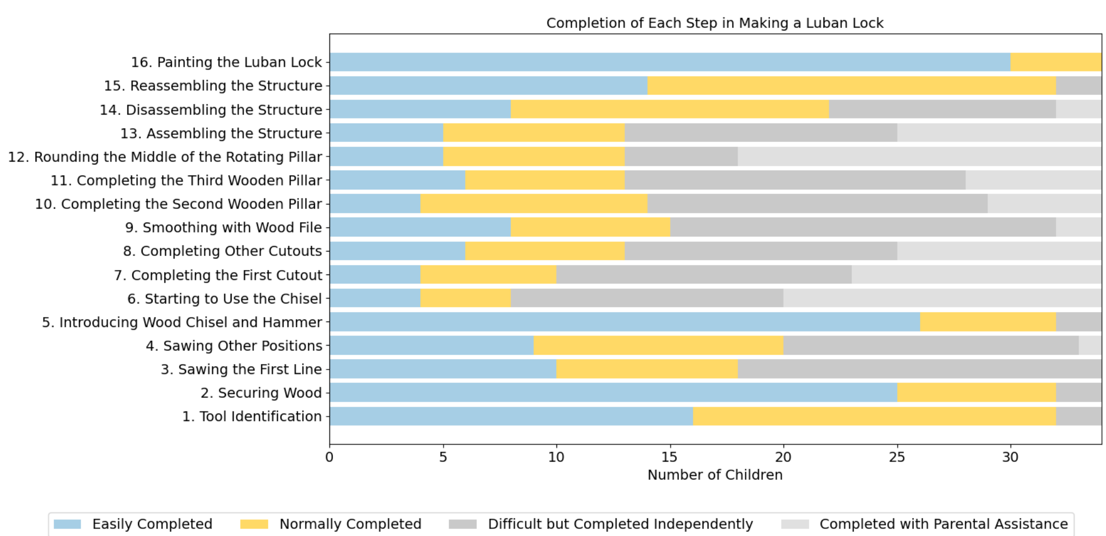

Fig. 9. Statistics on the completion of each step in making a Luban lock

These findings suggest that the challenges associated with specific steps were disproportionately concentrated in tasks requiring precision craftsmanship and assembly, highlighting the critical role of parental guidance during these stages for younger participants.

(3) Primary aspects

In the self-evaluation process for children, three primary aspects were assessed: safety (injury status), performance evaluation, and feelings about the challenge. A total of 24 self-evaluation items were included.

The injury status evaluation primarily focused on children's safety awareness and the effectiveness of parental supervision. Results showed that none of the children sustained injuries during the activity. The performance evaluation aimed to assess children's perception of the challenge's difficulty. Most children reported that the challenge was moderately difficult but manageable, with eight children indicating they were unable to complete the task independently and required significant parental assistance.

Feelings about the challenge constituted the core aspect of this evaluation, examining various outcomes such as parent-child relationships, children's sense of achievement, self-confidence, interest development, practical skills, spatial imagination, cognitive awareness, cultural understanding, and physical development. Each question employed a five-point Likert scale, ranging from 5 (strongly agree) to 1 (strongly disagree), yielding a Cronbach's Alpha of 0.729, indicating acceptable reliability. Based on the results, responses were scored as follows: positive evaluations scored 1-point, neutral evaluations scored 0 points, and negative evaluations scored -1 point.

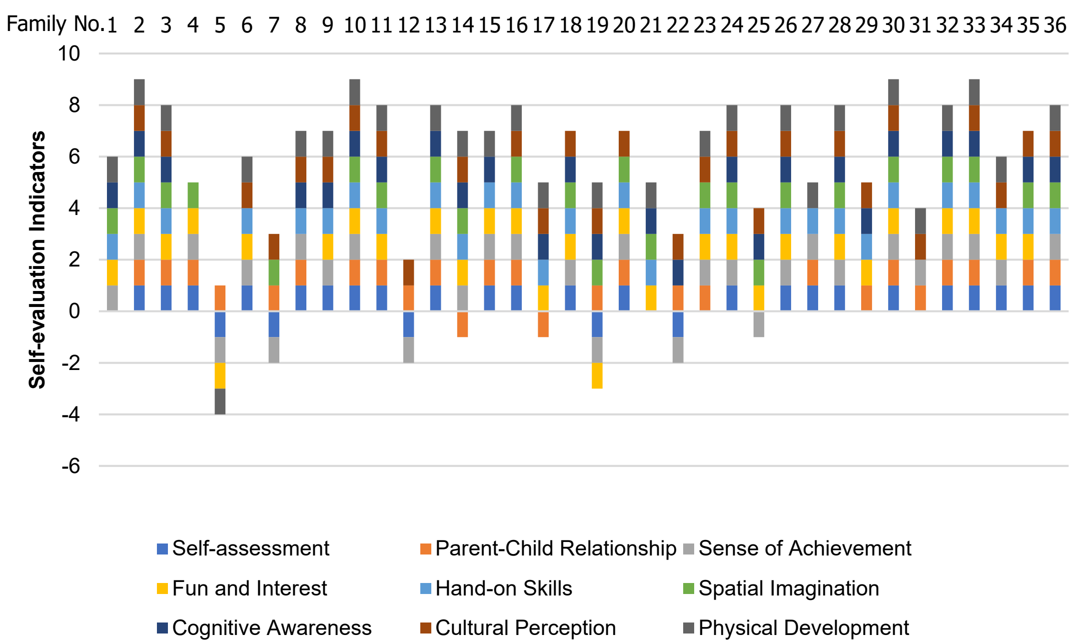

Fig. 10. Stacked bar chart of self-evaluation indicators

As shown in Fig. 10, the statistical analysis revealed that the mean score of children's evaluations was 0.66, indicating a generally positive feedback trend. As shown in Fig. 6, the evaluation items with the highest variability were 'performance evaluation' and 'sense of achievement'. Figure 11 highlights significant individual differences in children's performance and feelings toward the same task. A comparative analysis with Table 1 revealed a positive correlation between the total self-evaluation score for the challenge and both the completion level of the interlocking block (Luban lock) task and the amount of parental assistance. In contrast, the total self-evaluation score was negatively correlated with the number of failed attempts and the total time taken to complete the task.

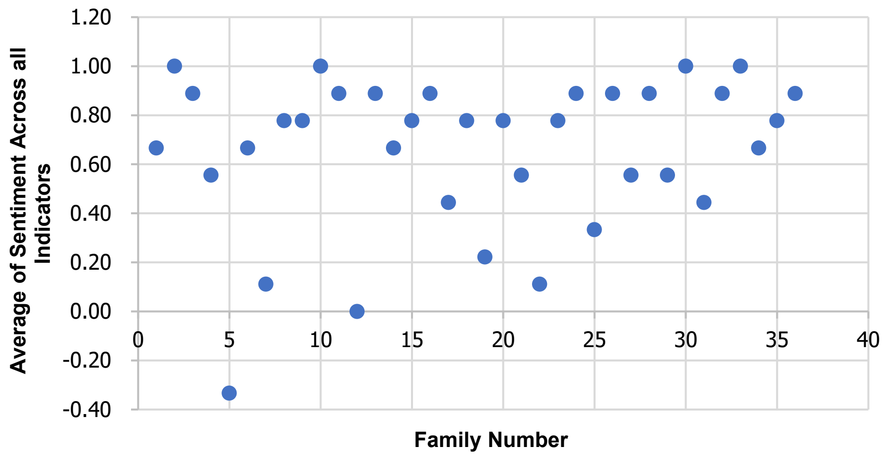

Fig. 11. Stacked bar chart of self-evaluation indicators

(4) Outcomes

This study examined the outcomes of a challenge involving the construction of a six-pillar Luban lock among children. The results indicate that only three participants (8.3%) successfully completed the task within the allocated time frame. Post-challenge interviews with families revealed the following insights:

- Time constraints: Six families reported that their children had limited discretionary time. While they expressed interest in the activity, they had not yet attempted it.
- Skill barriers: Twenty-three families noted that their children were unable to complete the challenge without structured and targeted instruction.
- Lack of interest: Four families stated that their children had lost interest in pursuing the Luban lock project further.

The six-pillar Luban lock demonstrated a significant increase in complexity compared to its three-pillar counterpart. Although children had developed basic woodworking skills through the earlier project, the six-pillar design posed substantial challenges, particularly in the areas of spatial reasoning and accurate marking during assembly. These difficulties often resulted in frustration, suggesting that the cognitive and technical demands of this project exceed the developmental capabilities typical for this age group.

Parental feedback underscored the importance of providing detailed instructional resources tailored to the project. When families were left to independently source materials and guidance, issues such as diminished motivation, inadequate resources, misalignment with the project's requirements, and inconsistent instructional quality became apparent. The findings highlight the need for accessible, high-quality instructional videos to better support participation and learning outcomes.

These results emphasize the importance of scaffolding complex tasks for children and ensuring access to age-appropriate teaching materials in hands-on learning projects.

(5) Children's perceptions and objective setting for parent-child woodwork activities

This part focuses on children's perspectives regarding parent-child woodwork activities and the objective conditions under which these activities are conducted. Children were asked whether they enjoy family woodwork activities, whether they are willing to receive assistance from parents or peers, which types of woodwork projects interest them most, and their perceptions of the objective conditions for engaging in such activities.

Statistical analysis reveals that most children enjoy participating in parent-child woodwork activities, express interest in engaging in future projects, and are open to collaborating with parents or peers. A cross-tabulation analysis was performed on two variables: gender and preference for family woodwork activities. The Pearson chi-square test showed \(p = 0.935 > 0.05\), indicating no significant relationship between gender and preference for woodwork activities at this stage of childhood. However, preferences for project types varied by gender. Female children were more interested in carving and puzzle-based toy projects, while male children preferred transportation- and military-themed toy projects.

Regarding the objective conditions for family woodwork activities, a five-point Likert scale was used to evaluate five key indicators. Statistical analysis highlights several limitations: a lack of materials, tools, and instructional resources were identified as major constraints to conducting family woodwork activities. Among the indicators, availability of play spaces received the highest scores, suggesting that physical space is not a significant limiting factor. Opinions on the difficulty of the activities were more varied, likely reflecting differences in individual cognitive development levels, as is shown in Tab.2.

Table 2. Statistical Analysis of Objective Setting for Parent-Child Woodworking Activities

Category	Time	Difficulty	Venue	Materials and Tools	Tutorial video
Average	3.44	3.78	4.28	2.83	3.31
Median	4	4	4	3	3
Variance	1.911	1.321	0.606	1.514	1.818
Sum	124	136	154	102	119

The analysis of playtime availability reveals that time dedicated to family woodwork activities decreased with age. A cross-tabulation analysis of age and available playtime produced a Pearson chi-square test result of $p = 0.002 < 0.05$, indicating a significant correlation between age and time allocation for these activities. Older children were found to have less time available for engaging in parent-child woodwork. This study underscores the importance of addressing resource limitations to support family woodwork activities while recognizing the developmental and age-related factors that influence participation.

(6) Parental feedback and recommendations

As part of the subjective evaluation phase of the experimental observation record, each parent provided feedback and suggestions regarding the activities. Most parents expressed a positive view of the initiative, acknowledging its significance in enhancing children's hands-on skills, precision in measurement, error control, and proficiency in using tools. Additionally, they noted that the activities deepened children's understanding of materials, fostered an appreciation for traditional culture, and heightened their overall interest.

Some parents reported that their children successfully completed the activities independently, which gave them a strong sense of accomplishment. However, other parents highlighted certain challenges, such as the high difficulty level of some tasks. Long production times or excessive parental involvement were identified as factors that led to decreased patience, engagement, and satisfaction among children. Furthermore, a few parents expressed concerns about the safety risks associated with sharp tools.

Key recommendations from parents included the following:

Reducing Difficulty: Adjusting the complexity of projects to better match children's developmental levels and maintain their interest.

Incorporating a Reward Mechanism: Introducing incentives to encourage participation and enhance children's sense of achievement.

This feedback underscores the importance of balancing challenge and accessibility in family woodwork activities while addressing safety concerns to ensure a positive and enriching experience for both children and parents.

Building on the foundation laid by the questionnaire survey, the experimental data played a crucial role in validating the research hypotheses and providing deeper insights into the phenomenon under investigation. The data confirmed that family parent-child woodworking activities are feasible, particularly when tailored to the age and skill level of the children. Most children were able to successfully complete basic projects, while the completion rate for more advanced projects was lower. This finding supported the research hypothesis that woodworking activities need to be adapted to the capabilities of the participants.

Furthermore, the experimental data revealed significant differences in children's performance during woodworking activities. These differences were attributed to factors such as age, cognitive ability, and practical skills, highlighting the individual variability in children's engagement and achievement in woodworking tasks. This finding underscores the importance of considering individual differences in designing and implementing educational interventions.

Finally, the experimental data provided strong support for the research conclusion that family parent-child woodworking has a clear and positive impact on children's cognitive development. The rigorous analysis of the data allowed the research team to draw this conclusion with confidence, thereby contributing to the existing knowledge base on the benefits of hands-on, family-based educational activities.

The Value of Family-Based Parent-Child Woodwork Activities

According to Piaget (1931), children aged 7 to 12 possess certain motor, computational, and spatial awareness abilities that enable them to understand and manipulate relatively complex structures. Based on this understanding, the research team selected the traditional and widely recognized Luban lock as the woodwork project for this study. This choice required technical skills and spatial reasoning, ensuring the activity aligned with the target age group's developmental capabilities. Through the creation of Luban locks, combined with prior research findings, the study confirmed the feasibility and multifaceted value of parent-child woodwork activities for children in the target age group. The findings are analyzed as follows:

Family-based woodwork enhances children's physical activity while integrating elements of play and accomplishment. Using various tools and materials, children repeatedly practice and refine their motor coordination, finger dexterity, and operational skills. Such activities significantly contribute to the development of fine motor skills and overall limb coordination.

Embodied cognition theory emphasizes the role of physical sensations and motor systems in shaping thought processes, including conceptualization and logical reasoning (Ye 2015). Dewey's "learning by doing" philosophy posits that children's development cannot be separated from practical experience; learning and thinking arise from such experiences (Song 2022). During woodwork activities, children must observe, analyze, and manipulate materials and tools, considering their properties, technical processing, cultural significance, and aesthetic features. They then design, calculate, and create based on their needs and imagination. This creative process nurtures problem-solving skills, innovation, and imagination, fostering habits of creative thinking and enhancing observation and cognitive abilities (Baggs *et al.* 2020; Koziol *et al.* 2012). The restrictions imposed by materials, tools, and spatial conditions further challenge children to think critically, develop spatial awareness, and enhance early STEM skills.

Woodwork activities often require time, patience, and focus, teaching children self-regulation, calmness, and perseverance. These qualities are crucial for emotional development. Overcoming challenges and completing a project brings immense satisfaction and joy, instilling a sense of accomplishment and fostering self-esteem and confidence.

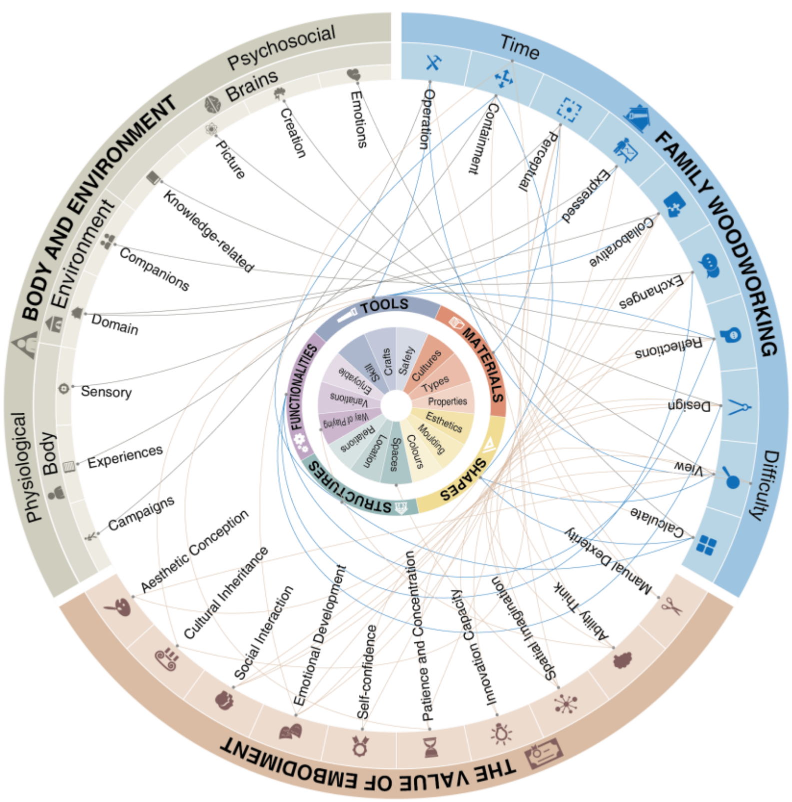

Fig. 12. The value of family parent-child woodworking

Embodied cognition also highlights the interconnectedness of mind, body, and environment. Woodwork activities immerse children in dynamic interactions with materials, natural rules, and social contexts. Collaborative projects with parents or peers promote teamwork, communication, and an understanding of roles and intentions. Sharing experiences and receiving feedback fosters emotional understanding and social awareness, while teaching respect for others' perspectives and contributions. Such interactions are pivotal for children's social and emotional development (Qiu 2013). Additionally, consistent observation of children by parents during these activities helps identify behavioral patterns and address developmental concerns.

Woodwork introduces children to the cultural origins, scientific principles, and aesthetic dimensions of projects, including color, shape, and proportion. This exposure deepens their cultural understanding and aesthetic judgment, fostering an appreciation for cultural heritage and artistic expression.

As is shown in Fig. 12, family-based woodwork engages children across multiple dimensions, including physical, cognitive, emotional, social, and cultural development. It enhances practical skills, critical thinking, spatial reasoning, creativity, patience, confidence, emotional intelligence, social interaction, cultural understanding, and aesthetic sensibility. These activities contribute to children's holistic development.

Contextualization and Limitations of Family-based Woodwork

The results of this experiment indicate that family-based woodwork is a popular, enjoyable, and challenging activity. While the findings are largely positive, the following recommendations are proposed to optimize the contextualization of these activities:

Safety is paramount in parent-child woodwork. Parents must supervise children throughout the process, promptly addressing potential hazards. This study observed zero injuries, which was attributed to the combination of careful experimental design, safety training, heightened safety awareness, and diligent parental supervision. Key risks include sharp tools, allergenic reactions to wood, harmful substances in surface treatments, and exposure to dust. To mitigate these risks, children should be taught proper tool usage and equipped with protective gear (*e.g.*, gloves, masks, goggles, and earplugs) as needed. When in doubt about the safety of a specific project or procedure, consulting an expert is advised.

Woodwork activities demand diverse skills, and children's abilities vary widely. Not all projects are suitable for every child. Parents should select activities based on children's cognitive characteristics and interests. Statistical results show that boys and girls are equally attracted to woodwork but exhibit distinct preferences for project types. Projects should be chosen to match children's developmental stage and "zone of proximal development" (challenging yet achievable), maximizing developmental outcomes and engagement.

Children aged 7 to 12 face academic pressures and limited free time, with older children having even less time available. Woodwork projects often require substantial time commitments. Parents and children should plan activities to avoid fatigue and negative emotions, ensuring a positive and productive experience.

Woodwork requires specific materials, tools, and consumables, which are often not readily available in households. Additionally, instructional resources and appropriate workspaces are necessary. These factors can limit the accessibility of woodwork activities. Developing detailed, engaging instructional resources tailored to family settings can help overcome these barriers and promote participation.

Despite positive outcomes, the study identified areas for improvement, such as children's varying levels of patience, focus, and motor skills. Parents' confidence in their children's abilities also varied. These findings highlight woodwork's potential to uncover developmental gaps and provide targeted support.

Future studies should deepen our understanding of family-based woodwork, refining its educational applications and practical frameworks to better support children's holistic development.

CONCLUSIONS

1. This study investigated the feasibility and value of family-based woodwork through an experimental approach involving 36 Chinese families. The selected projects—three-pillar and advanced six-pillar Luban locks—were used to assess children's performance and collect relevant data. Results confirmed that family-based woodwork has significant feasibility and high developmental value, benefiting children's physical, cognitive, emotional, and social growth while fostering cultural and aesthetic awareness.
2. However, notable individual differences in children's abilities highlight the need for tailored approaches. Projects should align with children's developmental stages and individual traits to maximize benefits. Further research is needed to explore a wider variety of woodwork projects and expand the study's scope beyond family settings to schools and community programs. While family woodwork should remain an optional activity, it offers valuable opportunities for children's growth and can complement other meaningful play-based learning approaches.

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Author Contributions

Conceptualization: All authors; Methodology: BIN SHANG and ZHE CHEN; Data collection: BIN SHANG; Data Analysis: HUI CHEN; Writing – original draft preparation: BIN SHANG; Writing – review and editing: ZHE CHEN; Funding acquisition: BIN SHANG.

Ethical Approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Conflict of Interest

The authors declare that they have no conflict of interest.

Informed Consent

No informed consent was required, because the data are anonymized.

Data Available Statement

The data that supports the findings of this study are available in the supplementary material of this article.

REFERENCES CITED

Abdelazeem, K., Al-Hussaini, A. K., El-Sebaity, D. M., and Kedwany, S. M. (2021). "Epidemiology, etiologies, and complications of playtime open globe injuries in children," *Journal of Pediatric Ophthalmology and Strabismus* 58(6), 385-389. DOI: 10.3928/01913913-20210426-01

Baggs, E., Raja, V., and Anderson, M. L. (2020). "Extended skill learning," *Frontiers in Psychology* 11, article 1956. DOI: 10.3389/fpsyg.2020.01956

Bank, D. E., and Carolan, P. L. (1993). "Cerebral abscess formation following ocular trauma: A hazard associated with common wooden toys," *Pediatric Emergency Care* 9(5), 285-288.

Borriello, G. A., and Liben, L. S. (2018). "Encouraging maternal guidance of preschoolers' spatial thinking during block play," *Child Development* 89(4), 1209-1222. DOI: 10.1111/cdev.12779

Cai, Z. and ACM. (2023). *Emotion Block: A Tangible Toolkit for Social-emotional Learning Through Storytelling* (WOS:001103422700087). 693-696. DOI: 10.1145/3585088.3594485

Cankaya, O., Rohatyn-Martin, N., Leach, J., Taylor, K., and Bulut, O. (2023). "Preschool children's loose parts play and the relationship to cognitive development: A review of the literature," *Journal of Intelligence* 11(8), article 8. DOI: 10.3390/jintelligence11080151

Chandler, P., and Tricot, A. (2015). "Mind your body: The essential role of body movements in children's learning. *Educational Psychology Review* 27(3), 365-370. DOI: 10.1007/s10648-015-9333-3

Chang, J.-H., and Yeh, T.-L. (2015). "The influence of parent-child toys and time of playing together on attachment," *Procedia Manufacturing* 3, 4921-4926. DOI: 10.1016/j.promfg.2015.07.628

Cheng, Y.-L., and Mix, K. S. (2014). "Spatial training improves children's mathematics ability," *Journal of Cognition and Development* 15(1), 2-11. DOI: 10.1080/15248372.2012.725186

Christopher, S. M., Urlings, C. C., van den Bongarth, H., Coppens, K. M., Hurks, P. P. M., Borghans, L., and Mockel, R. (2019). "A digital wooden tabletop maze for estimation of cognitive capabilities in children," in: *Social Robotics*, M. Salichs, S. Ge, E. Barakova, J. Cabibihan, A. Wagner, A. CastroGonzalez, and H. He, (eds.), Springer, Cham, Switzerland, pp. 622-632. DOI: 10.1007/978-3-030-35888-4_58

Dag, N. C., Turkkan, E., Kacar, A., and Dag, H. (2021). "Children's only profession: Playing with toys," *Northern Clinics of Istanbul* 8(4), 414-420. DOI: 10.14744/nci.2020.48243

Fan, Y., Chong, D. K., and Li, Y. (2024). "Beyond play: A comparative study of multi-sensory and traditional toys in child education," *Frontiers in Education* 9. DOI: 10.3389/feduc.2024.1182660

Foglia, L., and Wilson, R. A. (2013). "Embodied cognition," *Wiley Interdisciplinary Reviews: Cognitive Science* 4(3), 319-325. DOI: 10.1002/wcs.1226

Fu, J., and Chen, J. (2021). *The Intelligent Redesign of Traditional Chinese Wooden Toys from Embodied Cognition*, pp. 239-242. DOI: 10.1109/icsess52187.2021.9522284

Ginsburg, K. R. (2007). "The importance of play in promoting healthy child development and maintaining strong parent-child bonds," *Pediatrics* 119(1), 182-191. DOI: 10.1542/peds.2006-2697

Gunderson, E. A., Ramirez, G., Beilock, S. L., and Levine, S. C. (2012). "The relation between spatial skill and early number knowledge: The role of the linear number line," *Developmental Psychology* 48(5), 1229-1241. DOI: 10.1037/a0027433

Healey, A., Mendelsohn, A., Sells, J. M., Donoghue, E., Earls, M., Hashikawa, A., McFadden, T., Peacock, G., Scholer, S., Takagishi, J., Vanderbilt, D., and Williams, P. G. (2019). "Selecting appropriate toys for young children in the digital era," *Pediatrics* 143(1), article e20183348. DOI: 10.1542/peds.2018-3348

Hu, C.-C., Yang, Y.-F., Cheng, Y.-W., and Chen, N.-S. (2024). "Integrating educational robot and low-cost self-made toys to enhance STEM learning performance for primary school students," *Behaviour and Information Technology* 43(8), article 222308. DOI: 10.1080/0144929X.2023.2222308

Kauppinen, T., Vincent, R., Liukkonen, T., Grzebyk, M., Kauppinen, A., Welling, I., Arezes, P., Black, N., Bochmann, F., Campelo, F., *et al*. (2006). "Occupational exposure to inhalable wood dust in the member states of the European Union," *The Annals of Occupational Hygiene* 50(6), 549-561. DOI: 10.1093/annhyg/mel013

Koziol, L. F., Budding, D. E., and Chidekel, D. (2012). "From movement to thought: Executive function, embodied cognition, and the cerebellum," *The Cerebellum* 11(2), 505-525. DOI: 10.1007/s12311-011-0321-y

Li, Y., Hu W., Huang R., and Fu Q. (2022). "Construction and application of a game-based teaching model for cultivating children's computational thinking from the perspective of embodied cognition (in Chinese)," *Modern Educational Technology* 32(12), 109-117.

Liu, Y.-C., and Lee, A.-S. (2023). "Application of fuzzy theory to the investigation of children's preference for wooden toy materials—A case study of rocking horses," *Sustainability* 15(8), article 8. DOI: 10.3390/su15086356

Loisel, F., Bonin, S., Jeunet, L., Pauchot, J., Tropet, Y., and Obert, L. (2014). "Woodworking injuries: A comparative study of work-related and hobby-related accidents," *Chirurgie de La Main* 33(5), 325-329. DOI: 10.1016/j.main.2014.06.003

Luo Y., and Chen B. (2010). "A study on the interactive relationship among toys, environment, and children's exploratory behavior (in Chinese)," *Human Ergonomics* 16(3), 10-13. DOI: 10.13837/j.issn.1006-8309.2010.03.024

Perlin, J. (2005). *A Forest Journey: The Story of Wood and Civilization*, The Countryman Press.

Piaget, J. (1931). "Children's philosophies," in: *A Handbook of Child Psychology*, Clark University Press, pp. 377-391. DOI: 10.1037/13524-011

Qiu G. (2013). "From disembodiment to embodiment: The transformation of contemporary teaching thinking modes (in Chinese)," *Theory and Practice of Education* 33(1), 61-64.

Richards, M. N., Putnick, D. L., Bradley, L. P., Lang, K. M., Little, T. D., Suwalsky, J. T. D., and Bornstein, M. H. (2022). "Children's utilization of toys is moderated by age-appropriateness, toy category, and child age," *Applied Developmental Science* 26(1), 192-205. DOI: 10.1080/10888691.2020.1760868

Root, E., Willms, M., Steinkamp, M., Kettner, M., Coldewey, B., Koelle, M., Poloczek, C., Ananthanarayan, S., and Scharnowski, F. (2017). *Grasping Algorithms—Exploring Toys that Teach Computational Thinking*, J. Williamson and S. Schneegass (eds.), WOS:000463850100044; pp. 387-392. DOI: 10.1145/3152832.3156620

Singer, H., and Özşahin, Ş. (2023). "Analysis of key attributes of wooden toys via an interval-valued spherical fuzzy analytic hierarchy process," *Drvna Industrija* 74(2), 167-182. DOI: 10.5552/drvind.2023.0033

Song L. (2022). "Embodied thought in Dewey's philosophy and its educational implications (in Chinese)," *Journal of Education* 18(1), 33-43. DOI: 10.14082/j.cnki.1673-1298.2022.01.004

Song, Y., Yang, C., Gai, W., Bian, Y., and Liu, J. (2020). "A new storytelling genre: Combining handicraft elements and storytelling *via* mixed reality technology," *The Visual Computer* 36(10), 2079-2090. DOI: 10.1007/s00371-020-01924-3

Sosa, A. V. (2016). "Association of the type of toy used during play with the quantity and quality of parent-infant communication," *JAMA Pediatrics* 170(2), 132-137. DOI: 10.1001/jamapediatrics.2015.3753

United Nations. (2022). *World Population Prospects 2022: Summary of Results*. https://population.un.org/wpp/

Verdine, B. N., Golinkoff, R. M., Hirsh-Pasek, K., Newcombe, N. S., Filipowicz, A. T., and Chang, A. (2014). "Deconstructing building blocks: Preschoolers' spatial assembly performance relates to early mathematical skills," *Child Development* 85(3), 1062-1076. DOI: 10.1111/cdev.12165

Wang, X., Takashima, K., Adachi, T., and Kitamura, Y. (2021). "Can playing with toy blocks reflect behavior problems in children?" in: *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, pp. 1-14. DOI: 10.1145/3411764.3445119

Wang, Z., Liu, Y., Li, T., Zhang, Q., Bai, H., Cai, Y., and Lv, Q. (2021). "Wood preservatives in children's wooden toys from China: Distribution, migration, oral exposure, and risk assessment," *Ecotoxicology and Environmental Safety* 209, article 111786. DOI: 10.1016/j.ecoenv.2020.111786

Weisberg, D. S., Hirsh-Pasek, K., and Golinkoff, R. M. (2013). "Guided play: Where curricular goals meet a playful pedagogy," *Mind, Brain, and Education* 7(2), 104-112. DOI: 10.1111/mbe.12015

Yang, D. (2017). "Toys for intelligence enhancement: The influence of "modular" characteristics of construction toys on children's creative intelligence (in Chinese)," *Art and Design Research* 4, 84-87.

Yang, D. (2019). "Design of construction toys in the context of traditional craft inheritance (in Chinese)," *Packaging Engineering* 40(6), 195-201. DOI: 10.19554/j.cnki.1001-3563.2019.06.033

Yang, W., Liu, H., Chen, N., Xu, P., and Lin, X. (2020). "Is early spatial skills training effective? A meta-analysis," *Frontiers in Psychology* 11, article 1938. DOI: 10.3389/fpsyg.2020.01938

Ye, H. (2015). "Body and learning: Embodied cognition and its challenge to traditional educational views (in Chinese)," *Educational Research* 36(4), 104-114.

Zhan, Z., Li, Y., Mei, H., and Lyu, S. (2023). "Key competencies acquired from STEM education: Gender-differentiated parental expectations," *Humanities and Social Sciences Communications* 10(1), 1-10. DOI: 10.1057/s41599-023-01946-x

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