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Design and Development of an Interactive Vest for Enhancing the Cognitive and Motor Skills of Preschool Children

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Abstract

The preschool period plays a vital role in a child's overall development. Designing engaging educational environments and learning tools that correspond to children's developmental characteristics during this stage is a key factor in enhancing cognitive and motor skills. This study aimed to design and develop an interactive educational vest as an innovative learning tool that extends beyond its conventional function as clothing to serve as an educational medium. The research employed a descriptive, applied, design-based methodology. Preliminary data were collected through a literature review on the foundations of child development, clothing design, play-based learning, and aesthetic principles. Following an analysis of developmental needs, two educational vest prototypes—one for girls and one for boys were designed and constructed using materials such as fabric and felt. The vests incorporate a variety of interactive components, including zippers, buckles, buttons, geometric shapes, a teaching clock, the water cycle, and thematic puzzles, all designed to enhance hand–eye coordination, improve concentration, foster problem-solving abilities, and facilitate the learning of fundamental concepts such as numbers, colors, and nature. The findings indicate that integrating aesthetic principles with interactive features significantly enhances visual appeal, increases children's motivation, and encourages their active participation in the learning process. As practical tools for indirect instruction, the educational vests transform learning into a play-based experience, thereby contributing effectively to the development of preschool children's cognitive abilities and fine motor skills. The study suggests that the design of interactive educational clothing can serve as an innovative complementary approach within early childhood education systems.

Keywords: Interactive educational vests, Cognitive skills, Motor skills, Preschool children.

1 | Introduction

Early childhood, particularly the preschool years, is regarded as one of the most critical stages of human development. During this period, the foundations of children's cognitive, motor, emotional, and social

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capacities are established, forming the basis for their future learning and behavior. Research in the fields of education and developmental psychology has demonstrated that the quality of educational experiences during these formative years has a direct influence on the development of executive brain functions, problem-solving abilities, creativity, motor coordination, and communication skills. Consequently, the design of educational environments and learning tools that are aligned with children's developmental characteristics is considered one of the most effective strategies for improving the quality of preschool education [1]. In recent decades, educational approaches have shifted away from traditional information-transmission methods toward active, experiential, and play-based learning. Within this perspective, the child is regarded as an active learner who constructs knowledge and develops skills through interaction with the environment, direct experience, and play. Play is not merely a source of entertainment; it is also an effective means of fostering memory, attention, perception, thinking, creativity, social skills, and motor abilities [2] Accordingly, both the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the United Nations Children's Fund (UNICEF) have emphasized the importance of incorporating play-based learning approaches into early childhood education [3]. Cognitive and motor development in children are not independent processes; rather, they are closely interconnected and mutually reinforcing. Neuroscience research has shown that purposeful motor activities stimulate neural networks associated with memory, attention, planning, and executive functions, thereby enhancing learning and cognitive development [4]. Moreover, activities that require coordination between the eyes, hands, and other body movements contribute to improved concentration, faster information processing, and greater cognitive flexibility in children. Consequently, the design of educational tools that simultaneously engage both cognitive and motor domains has become a significant focus of interdisciplinary research in the fields of industrial design, educational sciences, and apparel design [5]. Among educational tools, smart and interactive garments possess considerable potential for creating active learning experiences due to their direct contact with the body, freedom of movement, and continuous interaction with the user. Advances in wearable technologies, smart textiles, sensors, and interactive design have enabled the development of garments that, in addition to their protective function, also serve educational, rehabilitative, and cognitive purposes. By incorporating elements such as color, texture, movable components, attachable parts, tactile or auditory feedback, and play-based activities, these products can encourage children to engage in purposeful tasks and promote active learning [6]. Despite the recognized importance of the relationship between movement, play, and learning, relatively limited research has been conducted on the design of interactive educational garments for preschool children, particularly products capable of simultaneously enhancing both cognitive and motor skills. This research gap highlights the need for designing products that, while adhering to the principles of ergonomics, safety, and visual appeal, encourage children to engage in cognitive and motor activities simultaneously. Accordingly, the present study aims to design and develop an interactive vest to enhance the cognitive and motor skills of preschool children. Drawing upon the principles of user-centered design, play-based learning, and interactive design, this research seeks to develop a prototype of an educational vest that promotes attention, concentration, motor coordination, active participation, and cognitive development in children aged 3 to 5 years through sensory–motor activities.

2 | Literature Review

Research related to the present study can be examined from two main perspectives: (1) cognitive and motor development in children, and (2) the design of interactive educational clothing and products. In the field of cognitive and motor development, numerous studies have emphasized the role of play-based and movement-oriented activities in enhancing children's mental abilities. demonstrated that the implementation of creative, play-based activities resulted in a significant improvement in the creativity and cognitive flexibility of preschool children [7]. Similarly in a study examining the design components of children's clothing, reported that the harmony between color, form, fabric characteristics, and children's developmental needs plays a significant role in enhancing the visual appeal of garments and motivating children to interact with their environment [8]. Subsequently, researchers increasingly focused on the role of movement-based play in the simultaneous development of cognitive and physical skills. Alikhani et al. reported that the implementation

of creative movement games improved fundamental motor skills, limb coordination, and the active participation of children aged 4 to 6 years [9]. Likewise, Kaviani et al. [10] demonstrated that strengthening executive functions—including attention, working memory, and cognitive control—facilitates the acquisition of motor skills [10]. In addition, Kiani-Moghadam and Bakhtiari [11] considered cognitive, social, and moral development as interrelated processes and emphasized the necessity of designing multidimensional learning environments for children [11]. In more recent studies, the role of interactive educational tools in enhancing cognitive and motor abilities has received increasing attention. Mohammadi and Marbini [11] demonstrated that the use of play therapy and interactive tools simultaneously improves cognitive skills, motor coordination, and problem-solving abilities in preschool children [12]. Ghaheri et al. [12] also reported a positive and significant relationship between motor coordination skills and cognitive–emotional empathy, suggesting that the enhancement of motor activities can contribute to the development of children's social skills. Furthermore, Sarvi Shadegan [14], in an investigation of the impact of color in children's clothing design, showed that the deliberate selection of colors can influence children's motivation, relaxation, concentration, and cognitive performance. At the international level, numerous studies have also emphasized the importance of designing interactive tools for children's learning. Hsiao et al. [15] demonstrated that the use of motion-interaction-based technologies improves learning performance, increases engagement, and enhances motor skills among preschool children. Similarly, Jylänki et al. [5] reported in a systematic review that programs based on physical activity and motor skills have a positive and significant impact on children's cognitive development, school readiness, and executive functioning [5]. also stated in their systematic review that interactive technologies and digital tools, when designed in accordance with children's developmental characteristics, can enhance learning, interaction, and active participation. On the other hand, Stopa and Chailerio [16], through their investigation of wearable technologies and smart textiles, highlighted the considerable potential of interactive clothing in the fields of education, healthcare, and rehabilitation, introducing it as an emerging area of product design [3]. A review of domestic and international studies indicates that, although numerous studies have been conducted on the role of play, motor activities, children's clothing design, and interactive technologies, most of these studies have focused on only one of these dimensions individually. To date, relatively few comprehensive studies have addressed the design and development of an interactive educational vest through an integrated approach combining apparel design, play-based learning, and the simultaneous enhancement of cognitive and motor skills in preschool children. Therefore, the present study seeks to partially address this research gap by designing and developing an interactive vest prototype and providing a practical model for the design of educational clothing for children.

3 | Research Methodology

The present study is applied in terms of its objective, as it aims to design and develop a prototype of an interactive educational motor vest for enhancing the cognitive and motor skills of preschool children and to provide a practical solution in the field of children's apparel design. In terms of methodology, this research falls within the category of design and product development studies. Initially, theoretical foundations, children's developmental needs, and the principles of interactive clothing design were extracted and analyzed through library research and the examination of scientific sources. Subsequently, based on the findings, the process of designing, prototyping, and constructing the interactive vest was carried out. This study adopts a qualitative approach, and the required data were collected through documentary research, content analysis of scientific sources, review of previous studies, and analysis of design principles and children's ergonomics. Ultimately, in terms of its nature, the research is considered descriptive–analytical, as it describes and analyzes the cognitive and motor characteristics of preschool children, as well as the effective components in educational clothing design, while explaining the structural, functional, ergonomic, and aesthetic features of the interactive vest and its design and development process.

4 | Findings

Based on the theoretical foundations of the study, the results obtained from the review of scientific sources, the analysis of the developmental needs of children aged 3 to 5 years, and the defined educational objectives, the design process of the interactive vest was carried out in several stages. Initially, a series of preliminary sketches was developed through the use of storyboards and educational scenarios, with an emphasis on the simultaneous enhancement of cognitive and motor skills. These sketches were evaluated in terms of visual appeal, compatibility with children's developmental characteristics, ergonomics, safety, interactivity, educational functionality, and ease of use. After implementing the necessary modifications, two final prototypes, including a girls' interactive vest and a boys' interactive vest, were designed and constructed. In both prototypes, the educational and interactive elements were positioned in a manner that, while creating motivation for play and learning, provided opportunities to strengthen cognitive skills, visual perception, problem-solving abilities, hand-eye coordination, fine motor skills, and self-care abilities. Although the functional structure of both vests is similar, differences were considered in the selection of colors, visual narratives, types of elements, and organization of activities according to the specific design approach of each model. In the following sections, the design characteristics, interactive components, and educational objectives of each prototype are described separately. The line sketches of the two selected models are presented in *Fig. 1*.

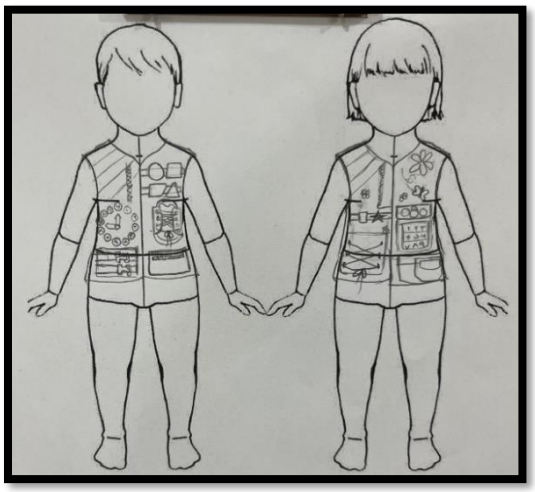


Fig. 1. Final approved line sketches of the selected models.

1.4| Model 1: Boys' Interactive Educational Vest

The prototype developed in this study is an interactive educational vest designed for boys aged 3 to 5 years, to enhance cognitive skills, strengthen fine motor abilities, improving hand–eye coordination, and teach fundamental concepts through play-based learning. In designing this vest, efforts were made to integrate educational activities into the structure of the garment through interactive elements that are appropriate to children's developmental characteristics. This enables children to gain an active and enjoyable learning experience through direct interaction with the components of the vest. The main body of the vest is made of medium-weight denim fabric. This fabric was selected due to its suitable strength, resistance to the weight and pressure caused by attaching educational components, ability to maintain garment shape and structure, and high durability during repeated use. Furthermore, the medium thickness of the fabric provides sufficient resistance while preserving children's freedom of movement and preventing excessive heat accumulation. For the construction of the interactive components, colored felt, complementary fabrics, decorative trims, and various accessories were used to enhance durability while providing a multisensory and engaging experience for the child. On the front section of the vest, a set of geometric shapes, including circles, squares, rectangles, and triangles, has been designed. These shapes are made of colored felt and attached to the vest using snap fasteners. The ability to detach and reattach these components familiarizes children with basic concepts of geometric shapes, colors, classification, and visual matching, while simultaneously strengthening hand–eye

coordination, precision, and fine motor skills. Another interactive feature of the vest is a buttoned pocket, through which children learn the function of buttons by practicing opening and closing it.[15] This activity helps develop finger control, motor coordination, and independence in performing daily tasks. In addition, a lace-up shoe model has been incorporated into the vest, allowing children to practice tying and untying shoelaces, thereby enhancing self-care skills, motor coordination, and the ability to perform everyday activities independently.

Another section of the vest features a zippered pocket, through which children learn how zippers function through repeated use while practicing fine motor skills, finger movement control, and hand–eye coordination. Additionally, a pocket equipped with a lobster clasp has been incorporated into the vest to familiarize children with different types of fasteners used in clothing and to enhance their self-care abilities. Another educational component of this vest is a puzzle car made of felt pieces, which is attached to the garment using fabric fasteners. Children can detach the pieces and reassemble them in their correct positions. In addition to increasing engagement and motivation for play, this activity strengthens problem-solving abilities, improves concentration, enhances precision, develops spatial perception, and promotes an understanding of part–whole relationships. The educational clock incorporated into the vest is also made of felt and fabric and includes movable numbers and adjustable hands. This component provides an opportunity to teach basic concepts of time, number sequencing, counting, and the direction of clock-hand movement, while strengthening children's cognitive skills and understanding of fundamental mathematical concepts. On the back of the vest, an airplane and clouds are embroidered as decorative motifs. The airplane's flight path is designed with a dashed line to symbolically convey concepts of movement, travel, exploration, and adventure to the child. In addition to enhancing visual appeal, this illustration provides a foundation for storytelling, imagination development, and the enhancement of linguistic and cognitive skills. In terms of color scheme, blue has been selected as the dominant color of the vest. This color, by creating a sense of calmness, security, confidence, and concentration, provides a suitable environment for engaging in educational activities [14]. Furthermore, the use of educational elements with diverse and contrasting colors against the blue background increases visual contrast, attracts children's attention, facilitates the recognition of components, and enhances visual perception. Overall, the integration of children's clothing design principles with interactive elements and educational activities in this prototype creates an appropriate context for play-based learning while simultaneously supporting the development of cognitive, perceptual, motor, and self-care skills in preschool children. The implementation process of this model is presented in *Fig. 2*.



Fig. 2. Implementation process of Model 1.

4.2 | Model 2: Girls' Interactive Educational Vest

The second prototype developed in this study is an interactive educational vest designed for girls aged 3 to 5 years, intending to enhance cognitive skills, strengthen fine motor abilities, improving hand–eye coordination, foster creativity, and teach fundamental concepts through interactive, play-based activities. In designing this prototype, a nature-inspired and multisensory learning approach was adopted. Natural elements, vibrant

colors, and interactive activities were integrated into an educational garment to provide children with an engaging and meaningful learning experience through play.

The main body of the vest is made of medium-weight denim fabric. This material was selected because of its appropriate strength, resistance to the weight of the educational components, durability under repeated use, and ability to maintain the garment's shape. In addition, the moderate thickness of the fabric provides sufficient durability while ensuring the child's comfort during use and preventing excessive heat buildup. All fabric and felt components were assembled using embroidery floss (DMC thread) and hand stitching, a technique that not only enhances structural strength and durability but also gives the product a handcrafted, warm, and child-friendly appearance. The front section of the vest incorporates a variety of educational and motor-skill activities. The vest is fastened with a zipper, enabling children to practice zipping and unzipping the garment while dressing and undressing, thereby improving finger coordination and fine motor control. An interactive pocket is also positioned on the upper part of the vest, with its flap secured by a fabric tie. Opening and closing this pocket helps develop fine motor skills, promotes hand–eye coordination, and encourages the acquisition of self-care skills. One of the vest's principal educational features is an interactive weather and water cycle module, composed of felt elements such as the sun, moon, clouds, and other related symbols. These components are attached to the main panel using fabric fasteners, allowing children to detach, reposition, and rearrange them according to different weather conditions. In addition, a movable pointer incorporated into this section enables children to learn concepts such as change, selection, and the sequence of natural phenomena, thereby enhancing their understanding of the surrounding environment. Adjacent to this module, a felt rainbow made of brightly colored bands has been designed to increase visual appeal while helping children learn colors and develop visual perception. At the lower section of the vest, an interactive felt flower made from colorful felt pieces and movable googly eyes is attached to the garment with a snap fastener. The flower's petals are designed to rotate, creating a pinwheel-like motion that increases children's interaction with the product, strengthens motor coordination, and encourages play. In addition, a felt butterfly attached to the vest is incorporated into a counting activity, enabling children to become familiar with basic concepts of numbers and counting while interacting with the garment's educational elements. Another interactive feature of the vest is a felt ladybug that can be moved to different locations on the garment, helping to develop children's attention to detail, spatial perception, and hand–eye coordination. In addition, a felt pond containing colorful fish and a water lily has been incorporated into the design. All of its components are detachable and can be reattached, allowing children to combine, rearrange, and freely manipulate the pieces. This activity fosters creativity, imagination, problem-solving skills, and motor coordination through open-ended play. Another section of the vest features a webbing strap equipped with a buckle, enabling children to practice fastening and unfastening it. This activity helps strengthen fine motor skills, improve finger control, and develop independence in performing everyday tasks. On the back of the vest, an embroidered rabbit together with its favorite food serves as a decorative motif. In addition to enhancing the garment's visual appeal, this illustration provides opportunities for storytelling, stimulates imagination, supports language development, and encourages children to form an emotional connection with the product. In terms of color design, pink was selected as the dominant color of the vest [14]. By conveying a sense of softness, calmness, warmth, and joy, this color is well-suited to both the educational context and the target age group. Combined with the diverse colors used in the interactive elements, it enhances the garment's visual appeal, captures children's attention, and increases their motivation to participate in educational activities. Furthermore, the use of a wide range of colors throughout the vest not only creates visual harmony but also provides opportunities for teaching color recognition, strengthening visual perception, and encouraging greater interaction with the product. Overall, the integration of nature-inspired elements, multisensory activities, and interactive components transforms this prototype into a play-based educational tool that can

simultaneously support the development of preschool children's cognitive, motor, perceptual, and creative skills. The implementation process of this model is presented in *Fig. 3*.



Fig. 3. Implementation process of Model 2.

4.3 | Final Prototype

After completing the design process, preparing the individual components, and constructing the vest and its lining, the final prototypes were carefully assembled. Subsequently, all interactive elements were installed and securely fixed in their designated positions to ensure their quality, durability, and proper functionality. The completed prototypes are presented in *Fig. 4*.



Fig. 4. Final constructed prototypes.

5 | Conclusion

The present study aimed to design and develop interactive educational–motor vests for children aged 3 to 5 years, based on a play-based learning approach. Accordingly, two interactive vest prototypes were designed and constructed in accordance with the developmental characteristics of preschool children. Each prototype adopted a distinct design approach while integrating a variety of educational, cognitive, and motor activities into an interactive garment. The first model employed a dynamic and exploratory approach, incorporating elements such as geometric shapes, an educational clock, a puzzle car, various fasteners, and movement-related symbols to promote cognitive development, problem-solving abilities, hand–eye coordination, self-care skills, and the learning of fundamental concepts. The second model was developed using a nature-inspired and multisensory approach, featuring natural elements such as the weather and water cycle, a rainbow, flowers, butterflies, a pond, and fish. Combined with interactive activities and functional fasteners, these elements supported the development of creativity, sensory perception, fine motor skills, hand–eye coordination, and the acquisition of basic educational concepts. The design of these two prototypes

demonstrates that children's clothing can extend beyond its conventional function to serve as an active and interactive educational tool. Integrating educational concepts into the structure of a garment transforms learning from a purely theoretical process into a concrete, enjoyable, and play-based experience, encouraging children to participate actively in the learning process. Furthermore, incorporating interactive components such as zippers, buttons, buckles, straps, puzzles, and detachable pieces not only enhances the product's attractiveness but also provides an effective means of developing fine motor skills, hand–eye coordination, concentration, attention, visual perception, problem-solving abilities, and self-care skills. Moreover, the use of a storytelling approach throughout the design process, the selection of age-appropriate colors, the application of materials such as denim fabric and felt, and the integration of visual and tactile elements contributed to improving the overall user experience and strengthening children's interaction with the product. These findings indicate that educational clothing, when designed according to children's developmental needs, ergonomic principles, and the fundamentals of interactive design, can play a meaningful role in enhancing the quality of teaching and learning. Overall, this study demonstrates that the design and development of interactive educational motor vests represents an innovative approach in the field of children's apparel design. By integrating education, play, and motor activities, such garments can simultaneously support the development of preschool children's cognitive, motor, perceptual, and creative abilities. In addition to their potential application in preschools, kindergartens, and child development and rehabilitation centers, these products may also serve as a practical model for the design of a new generation of interactive educational clothing for children.

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