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Using a gesture interactive game-based learning approach to improve preschool children's learning performance and motor skills

Hsien-Sheng Hsiao, Jyun-Chen Chen*

National Taiwan Normal University, No.162, Sec. 1, Heping E. Rd., Da'an Dist., Taipei City 106, Taiwan, ROC

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A B S T R A C T

Children love to play games, and early childhood is a critical time for developing motor skills. This study combined gesture-based computing technology and a game-based learning model to develop a gesture interactive game-based learning (GIGL) approach that was suitable for preschool children. In this research, the ASUS Xtion PRO was used as a game-based device to build a virtual interactive learning environment for preschoolers. The aim of this study was to implement the GIGL approach to improve the learning performance and motor skills (namely, coordination and agility) of the participants. Based on a quasi-experiment involving 105 preschoolers (average age 5.5 years), the results showed that the participants who used the GIGL approach demonstrated better learning performance and motor skills than those who used the traditional activity game-based learning approach, and the statistics showed a significant deviation between the two approaches. Thus, this study provides additional evidence that using a GIGL approach is an effective learning method that improves both learning performance and motor skills to a greater extent compared with the traditional activity game-based learning approach.

1. Introduction

In gesture interactive game-based learning (GIGL), students use gesture-based interfaces (such as Microsoft Kinect, ASUS Xtion PRO, Nintendo Wii, etc.) to combine body movements with learning materials. This helps students to reinforce their memories, comprehend learning materials, improve their learning performance, and strengthen their motor skills in a student-centered context in which learners are actively engaged (Altanis, Boloudakis, Retalis, & Nikou, 2013; Chao, Huang, Fang, & Chen, 2013; Huang, Liu, Kao, & Huang, 2009; Lee, Huang, Wu, Huang, & Chen, 2012; Li, Wang, Wu, & Chen, 2014; Lu, Liu, Chuang, & Peng, 2012; Wu, Huang, & Chang, 2013). Early childhood is a critical period for developing motor skills (Chang, Huang, & Huang, 2010; Piao, 2010; Sun, Zhu, Shih, Lin, & Wu, 2010; Yang, Lin, & Tsai, 2014). Accompanied with positive reinforcement, sufficient instructional demonstration, and a suitable learning environment, exercise benefits the development of motor skills (Gallahue & Donnelly, 2003; Hsiao, Chen, & Hong, 2015; Piao, 2010). As an emerging technology, gesture-based devices have opened new opportunities for learning (Sheu & Chen, 2014). Teachers can observe students as they perform specific motions to solve learning tasks and obtain feedback directly from the playing screen. This entire process

* Corresponding author.
E-mail addresses: hssiu@ntnu.edu.tw (H.-S. Hsiao), cv999999999@yahoo.com.tw (J.-C. Chen).

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improves children's gross motor skills (Altanis et al., 2013; Hsiao et al., 2015; Huang et al., 2009; Li et al., 2014; Miller, Tsui, & Dearden, 2010).

As it is pivotal for children to learning from playing, it has found that game, especially those for children, play an important role in cognitive development (Mitchell & Savill-Smith, 2005) and reinforcing children's motor skills (Altanis et al., 2013; Huang et al., 2009; Li et al., 2014). Moreover, in Taiwan, according to the Educare Service Guidelines for Preschools, "every preschool should schedule gross-motor movement activity that involves perspiration for at least 30 min per day" (Ministry of Education, 2011). Combining motor movement activities and learning using a GIGL approach in preschools would meet this recommendation for daily physical activities. Between 2011 and 2014, New Media Consortium highlighted several times in the *Horizon Report* that both the game-based learning model and the gesture-based learning model provide preferable learning opportunities that allow students to interact in a multimedia learning environment. Motor skills development is crucial to children's learning because their cognitive learning is based on movement sensitivity (Gallahue & Donnelly, 2003; Sun et al., 2010). Therefore, numerous research has been devoted to creating a GIGL approach that is effective in enhancing children's learning performance and motor skills (Altanis et al., 2013; Huang et al., 2009; Li et al., 2014; Lu et al., 2012; Wu et al., 2013).

Preschool children (approximately 3–6 years old) are in the preoperational stage of cognitive development (ages 2 to 7), and they can recognize colors, shapes, and sizes and can use language to adapt to the world (Piaget & Inhelder, 1969). Pitchford and Mullen (2005) suggested that color preference, linguistic input, and developing color cognition may be linked. Moreover, according to the Educare Activity Curriculum Outline for the Preschool, "the six areas of curriculum guidelines for preschool include body movement, cognition, language, society, emotion and aesthetic feeling" (Ministry of Education, 2012). Thus, this study developed an interactive game using gestures called "The Goalkeeper" to teach the subject of "color recognition," which involved learning six different colors (namely, cognition) and their corresponding names in English (namely, language). This study hypothesized that the preschoolers' cognitive development and body movement would improve using the GIGL approach as posited by the research questions, which are presented in Section 3.

2. Related research

2.1. Gesture-based learning

The features of gesture-based devices allow the user as a controller to interact with the computer more directly through the use of motions and movements that are naturally performed in daily life (Johnson, Adams, & Cummins, 2012). People have used gesture-based devices to detect the location, direction, and activity records of an object in real-space (Hsiao et al., 2015). Low-cost and easily accessible gesture recognition technology that can accurately capture the natural movements of the human body has already been developed (Hsiao et al., 2015). The application of gesture-based computing technology in training and education is continually expanding (Sheu & Chen, 2014). Gesture-based learning involving body movements provides different learning channels for students, which helps them to understand learning materials more easily (Hostetter & Alibali, 2008; Tellier, 2008; Wilson, 2002).

Somatosensory interactive man-machine interfaces have been applied in the fields of entertainment, rehabilitation, and learning. Examples of technology in the learning field include the ASUS Xtion PRO somatosensory sensor and Kinect for Windows, which were released in 2011 and 2012, respectively (Wu et al., 2013). Microsoft Kinect and ASUS Xtion PRO are similar computing devices that are now becoming widely used, as they provide both range and video images at a reduced cost in comparison with previous generations of such devices (Farid & Sammut, 2014). Gesture-based computing devices such as Kinect, Xtion, and others are often used to improve learners' gross motor skills, memorization, aesthetic recognition, art learning ability, learning motivation, and learning performance in various disciplines (Altanis et al., 2013; Chao et al., 2013; Lee et al., 2012; Li et al., 2014; Lu et al., 2012; Wu et al., 2013). Additionally, the Nintendo Wii is one of the most utilized gesture-based devices in academic research (Sheu & Chen, 2014). The Wii console and interactive controller provide users with more interactive experiences than typical push-button controllers do (Lee, 2008; Miller et al., 2010). Moreover, the Wii console as a training simulator can improve users' fine motor control, visuospatial processing, hand-eye coordination, and two-dimensional depth perception (Hsiao et al., 2015).

Gesture-based computing devices are used to support teaching and learning within different sub-education domains, such as science and math education, general education, physical education, and other education-related fields (Sheu & Chen, 2014). For example, Altanis et al. (2013) used a Kinect learning game to help children with gross-motor skills problems and motor impairments improve skills that are required in their daily lives. Li et al. (2014) designed a motion-sensing curriculum for physical education using Microsoft Kinect. Additionally, Ochoa, Rooney, and Somers (2011) and Wheeler (2011) used the Wii remote as a device for their designed experiments and demonstration projects, which involved Newton's Third Law and simulations of weightlessness. Hsiao et al. (2015) used the Nintendo Wii remote to measure and train the hand motor skills of senior vocational school students. Chao et al. (2013) used the Microsoft Kinect sensor to build a learning system to improve university students' memorization of English vocabulary and phrases, while Lee et al. (2012) used the Microsoft Kinect sensor to build a near-authentic environment in which college students could be engaged in designated situations through their body movements. Moreover, Di Tore, Aiello, et al. (2012) and Di Tore, D'Elia, Aiello, Carlomagno, & Sibilio (2012) used Kinect to create a visual-motor game that improved fifth grade students' integration skills. Lu et al. (2012) used a webcam to design physically interactive games to teach the Minan dialect, focusing on third grade elementary school students. Furthermore, Wu