Buca Eğitim Fakültesi Dergisi,
2025, sayı 63, ss. 924-947

Derleme Makalesi

The Journal of Buca Faculty of Education,
2025, issue 63, pp. 924-947

Review Article

Embodied Learning Enhanced with Technology in Special Education: A Systematic Literature Review

Özel Eğitimde Teknolojiyle Zenginleştirilmiş Bedenlenmiş Öğrenme: Sistematik Bir Literatür İncelemesi

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Geliş Tarihi: *30.10.2024* ***Kabul Tarihi:*** *06.02.2025*

ABSTRACT

With the rapid development of technology, the potential of Embodied Cognition (EC) in educational environments is increasingly being explored. Various studies have been conducted based on Embodied Learning (EL) for individuals with special needs. In this study, a systematic review was made of the use of technology enhanced EL applications for individuals with special needs between 2013 and 2023. As a result of the systematic review, it was seen that there has been an increase in study in recent years. Studies have mostly been conducted at primary school and university levels and with individuals with Autism Spectrum Disorder (ASD). Experimental method, multiple baseline design, case study and mixed research method were used as research methods. Achievement and standardized tests, observations, scales, video recordings, interviews, and system logs have generally been used as data collection tools. The focus has been on the cognitive, motor and social-emotional development of individuals with special needs that can be achieved through EL applications. Kinect technology was the most widely used. However, there was also a trend towards studies that take into account the potential of camera systems and image processing technologies to process complex motion data in a wider area. The studies examined were rich in terms of evaluation methods. There are also studies emphasizing the importance of automatic evaluation systems.

Keywords: Embodied learning, technology in special education, systematic review.

ÖZ

Teknolojinin hızla gelişmesiyle birlikte, eğitim ortamlarında Bedenlenmiş Bilişin (EC) potansiyeli giderek daha fazla araştırılmaktadır. Özel gereksinimli bireyler için Bedenlenmiş Öğrenme (EL) temelli çeşitli çalışmalar yürütülmektedir. Bu çalışmada, 2013-2023 yılları arasında özel gereksinimli bireyler için teknolojiyle zenginleştirilmiş EL uygulamalarının kullanımına ilişkin sistematik bir inceleme yapılmıştır. Sistematik inceleme sonucunda, son yıllarda bu alana yönelik çalışmalarda bir artış olduğu görülmüştür. Çalışmalar çoğunlukla ilkokul ve üniversite düzeylerinde ve Otizm Spektrum Bozukluğu (OSB) olan bireylerle yürütülmüştür. Araştırma yöntemi olarak deneysel yöntem, çoklu temel desen, durum çalışması ve karma araştırma yöntemi kullanıldı. Veri toplama araçları olarak başarı ve standart testler, gözlemler, ölçekler, video kayıtları, görüşmeler ve sistem günlükleri kullanılmıştır. Çalışmalarda, EL uygulamalarının özel gereksinimli bireylerin bilişsel, motor ve sosyal-duygusal gelişimleri üzerine etkisine odaklanıldığı görülmüştür. En yaygın kullanılan teknoloji Kinect teknolojisi olmuştur. Bununla birlikte, karmaşık hareket verilerini daha geniş bir alanda işlemek için kamera sistemlerinin ve görüntü işleme teknolojilerinin potansiyelinin araştırıldığı çalışmalara doğru bir eğilim olduğu ortaya çıkmıştır. İncelenen çalışmalar değerlendirme yöntemleri açısından zengindi. Özellikle otomatik değerlendirme sistemlerinin önemini vurgulayan çalışmaların da mevcut olduğu görülmüştür.

Anahtar Kelimeler: Bedenlenmiş öğrenme, özel eğitimde teknoloji, sistematik inceleme.

INTRODUCTION

Embodied Learning (EL) is a concept that emphasizes that an individual's physical interactions and cognitive processes are involved in the learning process as a whole (Ale et al., 2022). EL is a contemporary approach that emphasizes the use of the body in educational practices. It scientifically supports and improves sensory-motor learning (Macrine & Fugate, 2020). EL pedagogy is attracting increasing attention from researchers and educators (Kosmas et al., 2019). With developing technology, whole-body or movement-based systems are now used, especially in learning environments. In systems based on whole-body interaction, cognitive development is supported dependent on the interaction with the body and the physical environment through sensory-motor activities (Mora-Guiard et al., 2017). In motion-based systems, the control of computers is based on a physical movement that they can detect, such as body movements, gestures, facial expressions and sounds (Georgiou & Ioannou, 2019).

Researchers have pointed out the positive effects of movement-based technologies (such as Wii, Kinect and Exergames) based on natural user interaction in the education of individuals with special needs (Kosmas & Zaphiris, 2023). Salem et al. (2012) examined the feasibility and effectiveness of the Nintendo Wii game system in the rehabilitation of children with developmental disabilities. It was revealed that there was a significant improvement in the children's motor skills and performance. Kusumaningsih et al. (2022) aimed to improve the basic cognitive, motor and academic abilities of children with special needs and provide an entertaining learning experience by using Kinect technology. Results of their studies showed that Kinect increases students' interest, curiosity and learning motivation. Kwon et al. (2022) used Exergame for children with developmental disabilities in their study and reported that such exercise games had an effect on the development of basic motor skills.

In the literature, studies on technology enhanced EL have been examined through systematic reviews. These reviews have aimed to reveal the potential of technology enhanced EL in educational environments. In their study, Malinverni and Pares (2014) aimed to present a systematic review of theoretical approaches, design strategies and evaluation methods for full-body interactive learning environments. Researchers have emphasized improving the methods for assessing EL. In their study, which aimed to reveal the theoretical foundations of EL, Skulmowski and Rey (2018) underlined that the degree to which the body is integrated into a task in EL is significant. Georgiou and Ioannou (2019) examined empirical study on EL in K-12 education and concluded that EL supports cognitive learning outcomes. Researchers stated that study on EL should be expanded and emphasized the importance of comparative studies with other educational approaches. Zhong et al. (2023) presented a systematic review of empirical studies on technology-enhanced EL. Their analysis revealed the relationship between the sample group and size, duration, topic distribution, research method, and measurement tools. Researchers have reported that conflicting results regarding cognitive load have emerged, studies on EL are unclear, and studies on EL supported by technology should be expanded. Also researchers emphasized that more empirical studies are needed on what technology is integrated into embodied activity and how it is carried out. The different learning types of each student, age groups, and strategies used are important for the effectiveness of EL environments (Georgiou & Ioannou, 2019; Malinverni & Pares, 2014; Zhong et al., 2023).

The number of studies conducted with individuals with special needs in technology enhanced EL environments is rapidly increasing (De Luca et al., 2024). The study results indicate that these environments can encourage learning and support the development of individuals with special needs. However, studies showing the trends in empirical studies on technology enhanced EL for individuals with special needs are still limited.

1.1. Embodied Cognition

"Embodiment" challenges the traditional view of the mind and cognition by emphasizing the importance of the body in cognitive processes. Empirical studies in recent years have led to a paradigm shift that now emphasizes the role of the body in understanding cognition (Foglia & Wilson, 2013). Embodied Cognition (EC) theorists typically examine the role the body plays in cognition and argue that the brain is not the only cognitive resource we have for solving problems (Farina, 2021). The basic assumption of the widely accepted Cattell-Horn-Carroll (CHC) theory of cognitive ability is similar and suggests that intelligence is both multidimensional and functionally integrated (Schneider & McGrew, 2012). CHC theory consists of three layers. Layer III represents general ability, while Layer II consists of 16 broad abilities. These broad abilities cover the many narrower abilities found in layer I (Caemmerer et al., 2020). This theory of cognition also emphasizes that these skill sets are interrelated and cannot be clearly separated (Schneider & McGrew, 2012). The CHC theory explains cognitive development in the broadest way (Schneider & McGrew, 2018). Glenberg (2010) states that memory and perception are affected by bodily movements. Bokosmaty et al. (2017) states that within the theoretical framework of EC, conceptual representations are based on different approaches, such as the perceptual, motor and emotional approaches.

1.2. EL Enhanced with Technology

Embodied pedagogy focuses on how to include the body and environment in the learning process (Yiannoutsou et al., 2021). Structuring knowledge involves a cyclical process in which the spatial organization and arrangement of both the student and the environment in which the action takes place, including specific objects, body positions, and movements are consciously shaped (Georgiou & Ioannou, 2021). EL-based activities support the development of skills by taking into account the interaction between the student and the learning environment (Wang et al., 2023). These learning environments provide physical interaction with objects and digital representations, emphasizing the important role of the body in interaction and learning (Ioannou & Ioannou, 2020). Johnson-Glenberg et al. (2016) proposed an embodied taxonomy in education with three structures: sensorimotoric engagement, gestural congruency and sense of immersion. Tran et al. (2017) reported the effects of the components of this structure on technology enhanced EL environments. They found that sensors such as the Nintendo Wii and digital dance mats increased sensorimotor interaction, that accurately simulating cognitive processes through physical movements increased gestural adaptation, and that natural user interfaces such as Kinect and Leap Motion provided a greater sense of immersion.

Embodied theory has led to the emergence of insights into how interactions between people, objects, and context can be designed (Kosmas & Zaphiris 2018). In this context, Dourish (2001) introduced the concept of "Embodied Interaction" (EI) in Human Computer Interaction (HCI) and tried to explain the role of this concept, defining it EI as the creation, activation and modification of meaning through interaction with artifacts. In line with technological developments, studies on innovative EI technologies have become a focus of attention (Kosmas et al., 2017). The role of motion-based technologies such as Kinect devices, the Wii, Wii Fit and Wii Balance Board in learning environments is a subject of interest for researchers. Educational researchers have pointed to the potential role of these technologies, which enable the combination of concrete interfaces and virtual and physical elements, in the learning process (Lindgren et al., 2016). Studies have reported that such experiences enhanced with digital technologies positively affect learner participation. Chandler and Tricot (2015) attributed this increase in learner participation to the sense of presence caused by the immersive experience offered by EL environments.

1.3. EL Enhanced with Technology for Individuals with Special Needs

The United Nations International Children's Emergency Fund (UNICEF, 2024) defines individuals with special needs in the following way: "When individuals with single or multiple forms of physical, mental or sensory impairments face attitudinal and environmental barriers, their human rights are ignored, and basic services and equal participation are taken away from them, they become disabled". Generally, types of disabilities can be examined in three groups depending on whether an individual has sensory, physical or cognitive disabilities. These can also be presented under 12 headings: intellectual disabilities, auditory disabilities, visual disabilities, physical disabilities, attention deficit and hyperactivity disorder (ADHD), language and speech difficulties (L/SD), emotional and behavioral disorders, specific learning disabilities, autism (ASD), cerebral palsy (CP), chronic disease and special abilities (MEB, 2006).

The potential of EL, in which physical movement is integrated with the act of learning, for people with special needs has also been examined in the literature (Martínez-Monés et al., 2019). EL applications can be used to support the education and training activities of individuals with special needs and to encourage their active participation in the learning process (Kosmas & Zaphiris, 2023). These applications, which allow natural interaction, offer a flexible learning environment to students with special needs and enable them to achieve the targeted learning outcomes (Tancredi et al., 2022; Ojeda-Castelo et al., 2021). Kang and Chang (2019) state that teaching that enables HCI is an alternative approach that supports the skill development of children with special needs. Kosmas et al. (2018) suggest that EL is a promising area in teaching and learning through movement-based technology for children with special needs. In this context, a systematic examination of the studies is important to determine which technologies are more effective in line with sample characteristics and skill acquisition (Yang et al., 2024). Understanding which technologies are used for different types of disabilities within EL and which technology is employed for which skill can guide future research. Based on this, this study aimed to examine the scope and quality of intervention studies carried out with individuals with special needs in technology enhanced EL environments. The sub-questions are as follows:

1. What are the general characteristics of the articles (publication year, research process, method and data collection, sample characteristics)?

2. What are the variables and technologies used in the articles?

METHOD

The systematic review model was used in this study. A systematic review is a comprehensive synthesis of all studies published in that field in order to find a solution to a problem, in which specific inclusion and exclusion criteria are used (Higgins & Green, 2011). The databases, keywords, and inclusion/exclusion criteria used to decide which studies to include in the systematic review were determined in line with the shared opinions of the two researchers, and a quality assessment list was prepared to support data extraction (The Joanna Quality Appraisal Score Sheet, 2017).

2.1. Search-Scan-Scrutinize Processes

First of all, a literature review was conducted using Web of Science and Scopus databases. The search was limited to social science and education studies, journal articles published in

English, intervention studies, and studies published between 2013 and 2023. The studies to be included in the research were accessed using the keywords presented in Table 1.

Table 1

Keywords

Search Criteria	Search Terms
Field	("Embodied Cognition" OR "Embodied Learning" OR "Gesture Based Applications" OR "Applications Enhanced with Technology")
Disability Groups	AND ("Hearing Impairment" OR "Autism Spectrum Disorder (ASD)" OR "Intellectual Disability (ID)" OR "Dyslexi" OR "Dyspraxia" OR "Learning Disability (LD)" OR "Speech/Language Disability (S/LD)" OR "Attention Deficit Hyperactivity Disorder (ADHD)" OR "Visually Impaired (VI)" OR "Cerebral Palsy (CP)" OR "Down Syndrome (DS)" OR "Motor Impairments (MI)" OR "Special Educational Needs (SEN)")
Tecnnologies	AND ("Kinect" OR "Nintendo Wii" OR "Augmented Reality (AR)" OR "Virtual Reality (VR)" OR "Leap Motion" OR "Wearable device")

In the first search, 116 studies were reached and 29 duplicate studies were removed. In the second stage, the titles and abstracts of the studies were reviewed. Thirty-nine studies that were irrelevant and whose full text could not be accessed were removed. The remaining 48 articles were reviewed. In the final stage, each of the 48 articles was examined in detail. Secondary studies such as surveys focusing on embodied cognition and individuals with special needs were excluded. In this context, studies that included the keywords but were based on the opinions of participants such as parents, caregivers, therapists and teachers were excluded from the study. Finally, it was determined whether the articles met the inclusion and exclusion criteria in Table 2. The studies were examined in line with these criteria and 24 articles remained.

Table 2

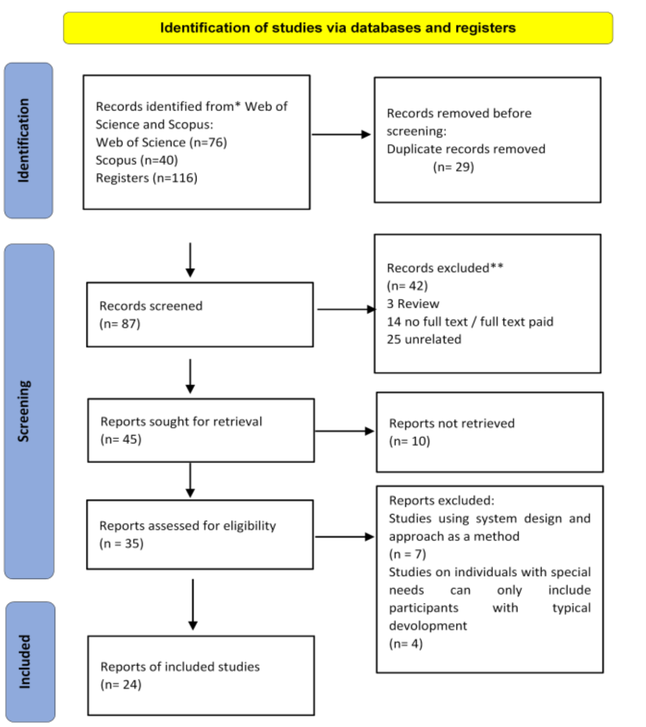
Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Englısh language	Not in Englısh
Social sciences and educational studys	Not primary study (e.g., review)
Journal articles	Not article (e.g., book chapter, conference paper)
Indexed in Web of Science and Scopus	
Primary study	

The systematic review was conducted taking into account the PRISMA reporting rules developed by Page et al. (2020) and is presented in Figure 1.

Figure 1

Systematic Review Process Carried Out Taking into Account PRISMA Reporting Guidelines



2.2. Data Extraction

In accordance with PRISMA reporting guidelines, the two researchers first read the titles and abstracts of the studies. Afterwards, the researchers read the full texts of the studies that met the inclusion criteria and agreed which studies would be examined. They prepared a rubric in an Excel file to support the data extraction process. Both researchers made the codings by considering the rubric criteria. The researchers came together to make comparisons and the final codes were decided upon after reaching a consensus. The coding included article citation (article year, name, authors), research process, method and data collection, sample information (number of participants, age group/education level, type of disability), skill developments focused on groups with different types of disabilities, and technologies used.

RESULTS

3.1. General Characteristics of the Articles on Technology Enhanced EL Applications

The author informations, publication years, research process, method and data collection, type of special needs focused on, number of participants and participants' age groups/education levels in the articles are presented in Table 3. In terms of distribution of the articles by years, there was one article from 2013, two from 2014, one from 2015, three each from 2016 and 2017, two from 2018, five from 2019, one from 2020, five from 2021 and one from 2023.

Table 3

General Characteristics of the Articles

Article Code	Author/s and Years	Research Process	Method and Data Collection	Participants	Age/Level
A1	Kosmas and Zaphiris (2023)	The study was carried out in four stages: A, B, C and D. In A, B and C, EL was implemented with the Kinems game. In D, EL was applied with the Panboy game developed by the researchers. C and D were carried out with typically developing students, A and B with individuals with special needs.	Mixed research method: system logs, standardized tests, semi-structured interviews and observations with teachers	211 MI, LD, typically developing (TD) students 21 teachers	Elementary students
A2	Lee (2021)	Social interaction scenarios were implemented in which the virtual 3D character was animated by participants using Kinect. The experiment consisted of three phases: baseline, intervention and maintenance.	Multiple baseline design: social story tests, five-point Likert scale, video recordings	3 ASD	7-9 years old
A3	Kang, Chang, and Howell (2021)	The experiment consisted of three stages. During the baseline and maintenance phases, participants brushed their teeth independently at school. During the intervention phase, students played a tooth-brushing game via Kinect.	Multiple baseline design: task analysis checklist, data collection sheet designed to record the task chain, video recordings, survey for parents and teachers	4 ID	7-11 years old
A4	Torres-Carrion, González-González, and Infante-Moro (2021)	While traditional teaching was provided in the control group in the study, participants in the experimental group performed some exercises for the development of reading skills on the TANGO:H platform, where they played active video games with Kinect.	In-depth case study: standardized tests, task analysis checklist, video recordings	6 DS	13-29 years old
A5	Kowallik, Pohl, and Schweinberger (2021)	Images of participants' faces were recorded with a video camera and processed in Python. In the experiment, participants were expected to watch and imitate six basic emotional expressions reflected on the screen.	Experimental study: video recordings, standardized tests	55 undergraduate students with varying degrees of ASD	18-31 years old
A6	Yiannoutsou, Johnson, and Price (2021)	In the study, a VR environment was designed to provide visually impaired participants with a location in terms of Cartesian coordinates. In the experiment, as participants moved they heard sounds from a speaker indicating their position relative to the grid lines.	Design-based case study: video recordings, observation notes	7 VI	8-11 years old

A7	Del Rio Guerra, and Martin-Gutierrez (2020)	Participants, whose full body movements were monitored via Kinect, were expected to perform a dance routine presented on a screen as a human silhouette. The researchers added gestures to the routines and participants were expected to make these gestures.	Experimental study: system logs (student personal information logs saved in SQLite), video recordings	36 DS	4-34 years old
A8	Hu and Han (2019)	The study consisted of three stages: initiation, intervention and maintenance. During the intervention phase, participants were taught how to use their hands and fingers in a 3-dimensional space with Leap Motion-supported VR technology for teaching matching skills. Participants performed the movements of grasping, holding and placing objects in the experiment.	Experimental study: video recordings, survey for teachers, observation notes	3 ASD	6-7 years old
A9	Degli Innocenti et al. (2019)	While only the traditional teaching method was used in the control group, a multiplatform mobile application, which was also a VR application, was used in the experimental group. The experiment involved participants visiting various music venues to learn musical genres in a 3D virtual environment and participating in musical performances of different genres using body movements.	Experimental study: achievement test, survey	10 SEN 16 TED children	10-11 years old
A10	Kang and Chang (2019a)	The experiment consisted of three stages. During the intervention phase, participants played the Kinect-based game and performed the hand-washing steps (taking the soap and placing it on the floor, rubbing and rinsing their hands, turning the water on and off).	Multiple baseline design: task analysis checklist, video recording, survey for teachers and parents	4 ID	Elementary school
A11	Kang and Chang (2019b)	The experiment consisted of three stages. During the baseline and maintenance phases, participants showered independently at home. During the intervention phase, participants performed showering steps (undressing, removing the hand shower, turning the water on/off) via Kinect.	Multiple baseline design: data collection sheets, video recording	6 ASD	9-11 years old
A12	Chiu et al. (2019)	The experiment consisted of three stages. During the intervention phase, children played a shopping game via Kinect. The game progressed with children using tokens on the screen to prepare some money and purchase an item from three stores (pharmacy, convenience store and grocery store).	Multiple baseline design: assessment based on paper-and-pencil test, survey for parents, audio recordings	4 ID	9-12 years old
A13	Kosmas, Ioannou, and Retalis (2018)	Two games were played with Kinect to develop children's visual-spatial and audio-visual memory skills. In the first game, children tried to find objects hidden in boxes, and in the second game, they tried to find sound pairs hidden in melody keys.	Mixed research method: memory test, Game-Usage analysis list, teacher observation notes and interviews	31 Low-level intelligence, brain paralysis, dyspraxia, LD, literacy and math, DS, emotional disorders, S/LD, ADHD, ASD (mild)	6-12 years old

A14	Hung et al. (2018)	In the study focusing on children's upper extremity (UE) training, children played Kinect2Scratch games. Because of the focus on movement training, an additional 30 minutes of traditional occupational therapy for hand function training was offered in each session.	Experimental study: scale, standardized tests, survey for parents	13 CP	5-15 years old
A15	Uzuegbunam et al. (2018)	The experiment consisted of three stages. During the intervention phase, participants used the Kinect-based MEBook, which was designed to address social greeting skills. Participants performed behaviors such as saying hello or goodbye, waving, and making eye contact.	Multiple baseline design: parental observations, video recordings, data collection sheet	3 ASD	7-11 years old
A16	Chuang et al. (2017)	A Kinect-based motion sensing game was developed to support the physical-kinesthetic intelligence development of participants. Each participant took on the role of a character and completed game stages of varying difficulty with the help of an NPC (non-player character) angel.	Semi-experimental study: clinical observation, five-point scale, interviews	3 CP	8-10 years old
A17	Cabrera et al. (2017)	The potential of the Kinect sensor to reduce involuntary movements of individuals with CP was examined. Participants were expected to perform a series of task-related voluntary movements using Kinect and Switch.	Experimental study: game-usage analysis list, observations, participant opinions	18 CP	9-55 years old
A18	Martínez et al. (2016)	In the experiment, KAPEAN digital games were played to understand participant behavior. Games were chosen to improve reasoning, attention and memory skills. An EEG headset was used together with the Kinect device to examine the participant's facial movements and emotional states.	Experimental study: surveys, system logs (EEG recordings)	15 ADHD	Participant age group not specified
A19	Neto et al. (2016)	A Kinect-based facial recognition system was used for visually impaired individuals. Participants were asked to find three people in front of them with 3D audio feedback through bone conduction headphones. The system allowed a mannequin to be recognized because it made a loud sound when touched.	Experimental study: video recordings, survey	3 blind 2 blind since birth	20-35 years old
A20	Sevick et al. (2016)	A free Internet video game with Kinect and FAAST software was used for UE motor training. In the experiment, participants played four different games to perform specific UE movements, for example, by lifting their right wrist to make a character in the game jump over an object. The sessions were completed at home and the necessary hardware and software were provided for the home.	Experimental study: video recordings, standardized tests, scale	4 CP	8-17 years old
A21	Kanwal et al. (2015)	For visually impaired individuals, a Kinect supported navigation system was used. The user was allowed to use the white cane with the automated system. This helped determine the best distance threshold for the user, allowing them to detect obstacles ahead.	Experimental study: video recordings, participant opinions	1 blindfolded person 1 VI	Adult

A22	Shih, Wang, and Wang (2014)	During the intervention phase, a Nintendo Wii was placed on the participants to reduce their hyperactive behavior. When participants stood up, the Wii vibrated and this continued until they sat down again.	Experimental study: system logs (experimental data were automatically recorded by the system)	2 ADHD	7 and 10 years old
A23	Chang, Shih, and Lin (2014)	In order to activate environmental stimulation for mentally disabled and obese students, a pedaling activity was carried out on an exercise bike. A control system continued to play the participant's favorite video while they pedaled continuously. When participants stopped pedaling, the control system paused the video playback.	Experimental study: system logs (the PDP software recorded participants' target responses within 3 min and transformed the received data to the system)	2 ID	16 and 17 years old
A24	Altanis et al. (2013)	The experiment was carried out in two stages. A Kinect-based game was played to detect the imbalance in the students' hands. The goal of the game was for students to perform basic exercises such as hand movements to develop their gross motor skills. Throughout the game, students guided a "girl" through complex paths with their hands.	Case study: system logs (3D data was recorded with the Kinect camera), therapist opinions	2 MI	Participant age group not specified

When Table 3 is examined, studies conducted with individuals with ASD in technology enhanced EL environments ranked first with a rate of 25% (n = 6). This was followed by 16.6% (n=4) of studies with ID and CP, 12.5% (n=3) with DS, ADHD and VI, 8.3% (n=2) with MI and LD, and 4.16% (n=1) with individuals with S/LD and SEN. Two studies included both individuals with disabilities and TD individuals as participants (A1, A9).

When examined in terms of the number of participants and age group/education level, 70.8% (n=17) of the studies involved 10 or fewer participants. While 45.83% (n=11) of the studies examined were conducted with primary school students, 25% (n=6) were conducted with university students, 12.5% (n=3) were conducted with middle school students, and 8.33% (n=2) were conducted with high school students. In the sample group, the percentage of studies in which adults were included as participants alongside children of primary school age and greater was 8.33% (A7, A17). In two studies, the age group of the participants was not specified (A18, A24).

While 54.16% (n=13) of the studies were carried out using the experimental method, a multiple baseline design was preferred in 25% (n=6), a case study was chosen in 12.5% (n=3), and mixed research methods were selected in 8.33% (n=2) of the studies.

When the data collection methods and techniques are examined, it can be seen that the data were collected through video and audio recordings, interviews with teachers, parents and therapists, students' opinions, observation notes, surveys, scales, standardized tests, achievement tests and system records.

3.2. Variables Examined in the Articles on Technology Enhanced EL Applications

The effects of technology enhanced EL applications on different skills or competencies were examined. The technologies used, the skills focused on, the types of disabilities and the results obtained are summarized in Table 4. The articles generally revealed positive outcomes of using technology enhanced EL practices, but there were articles that highlighted some challenges.

Table 4

Variables Examined in the Articles

Basic Skills	Sub-Skills	Types of Disabilities	Article Code (Technologies and Software)	Positive Conclusions	Negative Conclusions
Cognitive Skills	Short-Term Memory, Memory	MI, LD	A1 (Kinect)	√	
		LD, DS, S/LD, ADHD, ASD	A13 (Kinect)	√	
		ADHD	A18 (Kinect, EEG headset, leap motion)	√	√
	Reading Skills	DS	A4 (Kinect)	√	
	Spatial Ability	DS	A7 (Kinect)	√	√
	Level of Attention	ADHD	A18 (Kinect, EEG headset, leap motion)	√	√
	Mathematics Learning	VI	A6 (VR, HTC Vive)	√	
	Matching-To-Sample Skills	ASD	A8 (Leap Motion, VR)	√	
	Music Learning	SEN	A9 (VR headset)	√	
Language and Communication Skills	Expressive Vocabulary	MI, LD	A1 (Kinect)	√	
	Purchasing Skills	ID	A12 (Kinect)	√	
Motor Skills	Psychomotor Speed	MI, LD	A1 (Kinect)	√	
	Bodily Movement	VI	A6 (VR, HTC Vive)	√	
		DS	A7 (Kinect)	√	√
	UE Training- Hand Function Training	CP	A14 (Kinect)	√	√
		CP	A20 (Kinect, FAAST)	√	
		MI	A24 (Kinect)	√	
	Equilibrium, Skipping, Jumping, Sequential Finger Touching Skills	CP	A16 (Kinect)	√	
	Movement and Posture	CP	A17 (Kinect, Switch)	√	
		ASD	A22 (Nintendo Wii)	√	
	Exercise, Pedaling Activity	ID	A23 (Air Mouse, Exercise bike, mini-computer, pedal detection program, Nintendo Wii)	√	
Self-Care Skills	Tooth Brushing	ID	A3 (Kinect)	√	
	Hand Washing	ID	A10 (Kinect)	√	
	Shower Training	ASD	A11 (Kinect)	√	
Social-Emotional Skills	Self-Confidence, Joy, Enthusiasm, Calmness, And Motivation	MI, LD	A1 (Kinect)	√	
		CP	A20 (Kinect, FAAST)	√	
	Social Greetings	ASD	A2 (Kinect)	√	
		ASD	A15 (Kinect)	√	
	Emotion Recognition Performance , Imitation Performance, Instruction to Imitate	ASD	A5 (OpenCV2, Psychopy2 V1.82, Python)	√	
	Acceptability, Feasibility, and Satisfaction	ASD	A8 (Leap Motion, VR)	√	
	Enjoyability of the Experience	SEN	A9 (VR headset)	√	
	Engagement, Frustration, Meditation and Excitement	ADHD	A18 (Kinect, EEG headset, leap motion)	√	√
	Face Recognition	VI	A19 (Kinect, wearable device)	√	√
	Independent Living Skills with Navigation System	VI	A21 (Kinect)	√	

The studies examined were examined within the scope of basic skills and sub-skills. It was seen that 25% (n=6) of the studies examined focused on developing motor skills. This was followed by social-emotional skills at 20.83% (n=5), self-care skills at 12.5% (n=3), cognitive skills at 8.33% (n=2), and language and communication skills at 4.16% (n=1). Seven studies focused on the development of more than one skill. These skills were mostly cognitive (A1, A6, A7, A8, A9, A18), social-emotional (A1, A8, A9, A18, A20), motor (A1, A6, A7, A20), and language and communication skills (A1), respectively.

When the studies were examined in terms of which skill was focused on in which special needs group, cognitive, self-care and social-emotional skills were focused on in individuals with ASD; language and communication, motor and self-care skills were focused on in individuals with ID; motor skills were focused on in individuals with CP; cognitive, motor and social-emotional skills were focused on in individuals with ADHD; cognitive, motor and social-emotional skills were focused on in individuals with VI; cognitive, language and communication skills and motor skills were focused on in individuals with MI; cognitive, language and communication skill and motor skills were focused on in individuals with LD; and developing cognitive skills was focused on in individuals with DS, S/LD and SEN.

When the effects of using technology enhanced EL applications in special education were examined, positive effects were predominantly found. However, some difficulties were reported in four studies: technical problems caused by Kinect technology (A7, A14, A18), problems caused by the need for training in system use (A19), and problems caused by a decrease in participants' motivation as the sessions increased (A14).

3.3. Technologies Used in the Articles on Technology Enhanced EL Applications

Findings regarding the technologies used depending on the type of disability are presented in Table 5.

Table 5

Technologies Used for Individuals with Special Needs

Technologies	Type of Disability									
	ID	D	AS	CP	MI	LD	ADH	VI	S/L	SEN
Kinect	+	+	+	+	+	+	+	+	+	+
Kinect-Leap Motion			+							
Kinect- Wearable device								+		
Kinect-AR			+							
Kinect-Switch				+						
Kinect- EEG Headset- Leap Motion							+			
Kinect- FAAST				+						
Nintendo Wii			+							
Nintendo- Exercise bike- Air Mouse	+									
VR-HTC Vive								+		
VR- Headset										+
VR-Leap Motion			+							
OpenCV2-Psychopy2 V1.82-Python			+							

When Table 5 is examined, it is seen that 60% (n=6) of the studies were conducted with individuals with ASD, 30% (n=3) with individuals with VI and CP, 20% (n=2) with individuals with ID, ADHD and 10% (n = 1) with individuals with SEN, DS, MI, LD and S/LD. Kinect technology was used for skill development in individuals with all types of disabilities. In the studies examined, Kinect, VR, Nintendo and OpenCV2-Psychopy2 V1.82-Python were used most, in that order of frequency. These technologies were sometimes integrated with software (FAAST), other equipment (Switch, EEG headset, exercise bike, air mouse, HTC Vive, VR headset) and other motion-based technologies (Leap Motion, Wearable device). There were also studies in which the data obtained with Kinect was transferred to virtual environments such as AR and Leap Motion. There were also studies on the usability of different motion-based technologies other than Kinect, either alone (Nintendo) or through the use of various other equipment, to support skill development in individuals with special needs. In addition, in one study an image processing algorithm (OpenCV2-Psychopy2 V1.82-Python) was used to process motion data instead of a motion-based technology.

DISCUSSION, CONCLUSION AND SUGGESTIONS

The findings revealed that the number of studies conducted within the framework of EL for individuals with special needs has increased in recent years. Most of the studies reviewed included individuals with ASD. There were studies involving individuals with different types of disabilities. There were also studies in which individuals with special needs and individuals with typical development were included in the sample group. When the variables discussed in the studies were examined, the most frequently used variable for different types of disabilities was cognitive skills. Kosmas & Zaphiris (2023) stated that studies on EL applications in special education are aimed at the development of cognitive, social and motor skills. The findings obtained in the present study are thus compatible with the findings of other researchers. Self-care is an important skill for individuals with special needs in terms of their ability to live an independent daily life, and efforts to ensure that they acquire these skills could be increased. Additionally, Mino-Roy et al. (2022) pointed out the importance of providing individuals with special needs with education aimed at reducing destructive behaviors and anxiety and gaining self-confidence.

In the studies are examined, it was found that technology enhanced EL environments supported the development the social-emotional of individuals with ASD, cognitive and self-care skills. Individuals with ASD experience problems in skills such as establishing and maintaining communication with their peers (Mora-Guiard et al., 2017). They have difficulty understanding nonverbal social and sensory stimuli (Hu & Han, 2019) and perform poorly in fine motor skills (Mohd Nordin et al., 2021). Students with ASD have higher interest and participation in technologies that allow natural interaction (Lee, 2021). For this reason, technology enhanced EL environments can support and encourage individuals with ASD to socialize with other individuals, especially in their daily lives, and to gain academic and motor skills.

Contreras et al. (2019) stated that individuals with ID experience low self-esteem, communication-related socialization problems, involuntary movements, problems with balance, low fine motor mobility, poor memory, and difficulties in attention and decision-making. They have reported that technologies such as Nintendo, Kinect, and interactive video games can be used to activate the attention, planning, communication, motor, and learning skills of individuals with ID. In this review, it was seen that technology enhanced EL environments supported the development of self-care, language and communication, motor skills in individuals with ID. Gilbertson et al. (2020) stated that technology enhanced interventions are frequently used to improve functional mobility and increase physical activity by increasing intrinsic motivation. In this context, they reported that technologies such as VR are able to involve individuals with CP in an immersive experience, allowing them to enjoy the process and supporting their motor development. In this review, it is seen that the development of motor skills of individuals with CP is supported by the use of technology-supported EL environments. Torres-Carrión et al. (2019) stated that cognitive exercises performed in interactive environments contribute to the stimulation of visual-spatial memory and positive learning outcomes in individuals with DS. In this review, the development of cognitive skills in individuals with DS is supported in technology enhanced EL environments.

The result of this systematic review show that technology enhanced EL environments support the development of cognitive, social-emotional, and motor skills in individuals with ADHD. In a study which had similar findings to this, He et al. (2022) reported that movement-based technologies make the rehabilitation processes enjoyable and have positive effects on the development of skills such as motor skills, memory and self-control in individuals with ADHD. In addition, they have pointed out the importance of using wearable and image processing technologies in analyzing the behaviors of these individuals with objective and quantitative measurements. Xu et al. (2023) reported that movement-based technologies offer individuals with VI the opportunity to move safely and independently. They have stated that these technologies support the development of mobility skills of individuals with VI, as well as contributing to their acquisition of gains in the areas of self-care, improving the general quality of life, adaptation to social life and active participation. In the present review, the development of cognitive, motor, and social-emotional skills in individuals with VI are supported by technology enhanced EL environments. Roy et al. (2013) reported in their study that movement-based technologies encourage effective motor learning during the rehabilitation process, increase motivation, give information about the individual's performance through the system feedback provided by the technology, and perform better with each trial. In the present review, the development of cognitive, language and communication, and motor skills in individuals with MI were supported in technology enhanced EL environments. Flores-Gallegos et al. (2022) saw movement-based technologies as an effective teaching tool for individuals with LD. In this review, the cognitive of individuals with LD, language and communication, and motor skills were supported in technology enhanced EL environments. The results of the systematic review indicate that the development of cognitive skills in individuals with S/LD is supported in technology enhanced EL environments. Lekova et al. (2022) proposed a speech and language therapy system that can assist individuals with S/LD in educational processes and social contexts. By integrating a humanoid NAO type robot, brain headset, emotionally expressive robot EmoSan and a Kinect sensor into this system, they designed scenarios that will support the development of individuals' speaking, listening and understanding skills. These kinds of innovative practices have proven to be interesting and motivating for individuals with S/LD.

Of the studies examined 70.8% (n=17) were conducted with 10 or fewer participants. It was seen that 45.83% (n=11) of the studies examined included primary school students. This was followed by university students in 25% (n=6) of the studies, middle school students in 12.5% (n=3) of the studies, and high school students in 8.33% (n=2) of the studies. Zhong et al. (2023) pointed out that studies on technology enhanced EL environments are concentrated at the primary school level. They also emphasized that the number of participants in the studies was generally low. These results are similar to the findings of this systematic review. In addition, they drew attention to the scarcity of studies at the middle and high school levels and emphasized that the effectiveness of EL practices with these groups was still unclear. More studies could be carried out focusing specifically on groups at this level.

All the studies examined included an intervention for the participants. When the methodologies of the studies were examined in detail, it was found that the experimental method was frequently used. When the study results were examined, there was a statistical difference in favor of the groups in which movement-based technologies were used as experimental interventions. However, some results indicated that the length of the experimental interventions negatively affected students' motivation to participate in the process (A14). Another study emphasized the necessity for training in the use of technology (A19). Some studies pointed out the shortcomings of Kinect technology in motion detection and tracking (A7, A14, A18). Lee (2021) also described the limitations of Kinect in terms of field of view and combined Kinect with AR technology in his study. He stated that with AR technology, difficulties in motion detection are eliminated and reality is amplified in the visual environment presented. Also, he reported that different movement-based technologies can be combined and used to design learning environments that are facilitative, flexible, close to reality, and support social interactions for individuals with special needs.

When the data collection methods and techniques were examined, it was seen that video and audio recordings, interviews, observations, surveys, scales and tests, and system records were most frequently used. In some studies, data obtained with an EEG headset and Kinect camera were used. Since these systems automatically measure students' attention and motivation levels in the real classroom environment, they enable the relationships between mental and physical processes to be explained more clearly (Zhong et al., 2023). Kosmas and Zaphiris (2023) reported that studies on providing skills to individuals with special needs are generally carried out in laboratories and therapy centers, and stated that studies should be conducted on how to integrate EL practices into real classroom environments. Malinverni and Pares (2014) reported in their review that evaluation methods should be able to provide a deep understanding of the specific effects on learning outcomes. Zhong et al. (2023) drew attention to the importance of making multidimensional evaluations to ensure the permanence of knowledge and skills and the presence and participation of the learner. In this context, it is important to examine the potential of using tools in which the control is built into the system and data is recorded automatically in technology enhanced EL environments for individuals with special needs. In addition, studies that evaluate the ability of individuals with special needs to maintain the skills they have acquired, to continue to participate in the learning process, to practice self-management and to feel motivated, in addition to achieving academic success and acquiring skills, will be valuable.

This systematic review revealed that most of the studies used Kinect technology. However, there are also studies that used various software, equipment and technologies along with technologies such as Kinect, Nintendo Wii, Leap Motion. In the literature, EL environments mostly used Kinect devices (Georgiou & Ioannou, 2019). Kinect's affordability and ease of use by educators may have had an impact on this situation. Additionally, similar study results have revealed that there is an increasing interest in different gesture-based technologies (Nintendo Wii, Leap Motion) and an increased use of these technologies in learning environments (Dahn et al., 2018). In one study, an image processing algorithm was used in a Python-based experiment. These technologies are focused on cognitive skills, such as learning information and understanding concepts, and affective skills, such as increasing interest and motivation, and active participation; they also contribute to the development of psychomotor skills such as movement and control (Georgiou & Ioannou, 2019). However, some movement-based technologies may in some cases be inadequate for individuals with special needs (Gürbulak & Esgin, 2016; Kowallik et al., 2021). As an alternative to this situation, camera systems and image processing technologies have the potential to process complex motion data in a wider area (Elhayek et al., 2015). Image processing technologies allow for a great deal of information, including information about the learner's interest, motivation, emotional states, presence and engagement, to be accessed through cameras that take images at regular intervals (İşler & Kılıç, 2021). In this context, camera and image processing technologies have the potential to enable EL environments. Greater use of camera systems and image processing technologies can be encouraged in learning environments to support students' cognitive, affective and psychomotor development. In addition, More accessible and adaptable alternative teaching systems can be developed for individuals with special needs through the integration of current technologies such as AR, VR and artificial intelligence (AI) with movement-based technologies. It is important for special education teachers to be familiar with these technologies. Research can be conducted on how EL environments can be incorporated into individualized education programs.

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GENİŞLETİLMİŞ ÖZ

Giriş

Somut arayüzler ile sanal ve fiziksel unsurların birleşimine imkan sunan bedenlenmiş teknolojilerin, öğrenme sürecindeki önemli rolü eğitim araştırmacıları tarafından vurgulanmaktadır. Araştırmacılar, dijital teknolojilerle geliştirilmiş kinestetik öğrenme etkinliklerinin, öğrenen katılımını da olumlu yönde etkilediğini bildirmektedir. Öğrenen katılımını artıran bedenlenmiş öğrenme (EL) ortamları, öğrenenlere sürükleyici bir deneyim fırsatı sunarak varlık ve duygularının gelişimini desteklemektedir. Literatür incelendiğinde bedensel hareketin öğrenme eylemine entegre edildiği EL uygulamalarının, özellikle özel gereksinimli öğrencilerin çeşitli beceri ve yeterliliklerinin gelişimini desteklediği ortaya çıkmaktadır. Özel gereksinimli bireylerin, eğitim öğretim faaliyetlerinin desteklenmesi ve öğrenme sürecine aktif katılımlarının teşvik edilmesinde EL uygulamalarından yararlanılmaktadır. Özel gereksinimli bireyler ile teknoloji destekli EL ortamlarında yürütülen çalışmalar hızla artmaktadır. Araştırma sonuçları, bu ortamların öğrenmeyi teşvik edebileceği ve özel gereksinimli bireylerin gelişimlerini destekleyebileceği yönündedir. Özel gereksinimli bireyler için teknoloji destekli EL'ye yönelik ampirik çalışmaların eğilimini gösteren çalışmalar hala sınırlıdır. Bu bağlamda çalışmanın temel amacı, özel eğitimde teknolojiyle zenginleştirilmiş EL ortamlarının yer aldığı müdahale araştırmalarının kapsamını incelemektir.

Yöntem

Çalışmada, özel gereksinimli bireylerin eğitim süreçlerinde teknolojiyle zenginleştirilmiş EL ile ilgili yayımlanan akademik çalışmaları incelemek ve incelenen çalışmaları belirli kriterler çerçevesinde değerlendirmek amacıyla sistematik derleme yapılmıştır. Derlemeye, ilgili konu bağlamında 2013-2023 yılları arasında yayımlanan çalışmalar dahil edilmiştir. Literatür taraması, Web of Science ve Scopus veritabanları kullanılarak gerçekleştirildi. Arama, İngilizce olarak yayımlanan, sosyal bilimler ve eğitim araştırmaları, dergi makaleleriyle sınırlandırıldı.

İlk aramada 102 çalışmaya ulaşıldı ve tekrar eden 25 çalışma çıkarıldı. İkinci aşamada, çalışmaların başlık ve özetleri gözden geçirildi. İlgisiz ve tam metnine ulaşılamayan 30 çalışma çıkarıldı. Geriye kalan 47 makalenin incelemesi yapıldı. Son aşamada ise 47 makalenin her biri detaylı bir şekilde incelendi ve önceden belirlenen dahil etme- hariç tutma kriterlerine uyup uymadıkları belirlendi. Bu kriterler doğrultusunda çalışmalar incelendi.

Bedenlenmiş biliş ve özel gereksinimli bireyleri konu edinen ancak inceleme gibi ikincil araştırmalar kapsam dışında bırakıldı. Anahtar kelimeleri içerdiği halde ebeveyn, bakıcı, terapist, öğretmen gibi katılımcıların görüşlerine dayalı kurgulanan çalışmalar araştırma dışı bırakıldı. Yetersizliğe sahip bireylerin beceri gelişimine destek sunmayı amaç edinmesine rağmen tipik gelişim gösteren katılımcılarla yürütülen 4 çalışma daha çıkarıldı. Sonuç olarak 24 çalışmanın içerik analizi yapıldı. Sistematik inceleme iki araştırmacı tarafından, PRISMA raporlama kuralları dikkate alınarak yapılmıştır.

PRISMA raporlama kurallarına uygun olarak iki araştırmacı öncelikle çalışmaların başlık ve özetlerini okudu. Sonrasında araştırmacılar dahil etme kriterlerini sağlayan çalışmaların tam metinlerini okudu ve fikir birliği ile incelenecek çalışmalara karar verdi. Ardından, araştırmacılar veri çıkarımını desteklemek için hazırladıkları rubrikle içerik analizini gerçekleştirdi. Bulguların sunumunda kodlamalar iki araştırmacının ortak kararı ile gerçekleştirildi. Kodlama; makale künyesi (yayın yılı, yazar/lar, araştırma süreci, yöntem ve veri toplama, örneklem özellikleri), çalışmalarda odaklanılan değişkenler ve kullanılan teknolojiler şeklinde yapılmıştır.

Bulgular

Makalelerin yıllara göre dağılımına bakıldığında konu ile ilgili çalışmalara en çok 2019 ve 2021 yıllarında rastlanmaktadır. Yetersizlik türleri kapsamında incelendiğinde teknoloji destekli EL ortamlarında Otizm Spektrum Bozukluğu (OSB) olan bireylerle yapılan çalışmalar ilk sırada yer almaktadır. Katılımcı sayısı ve yaş grubu/eğitim düzeyi açısından incelendiğinde çalışmaların çoğunda 10 veya daha az katılımcının yer aldığı görülmektedir. İncelenen çalışmalar çoğunlukla ilkokul öğrencileri ve üniversite öğrencileri ile yürütülmüştür. Çalışmalar çoğunlukla deneysel yöntemle yürütülmüştür. Verilerin video ve ses kayıtları, öğretmen, veli ve terapistlerle yapılan görüşmeler, öğrenci görüşleri, gözlem notları, anketler, ölçekler, standart testler, başarı testleri ve sistem kayıtları aracılığıyla toplandığı görülmektedir.

İncelenen çalışmalar temel beceriler ve alt beceriler kapsamında incelenmiştir. Çalışmalarda çoğunlukla motor becerilerin geliştirilmesine odaklanıldığı görülmektedir. 7 çalışmada birden fazla becerinin geliştirilmesine odaklanılmıştır. Bu beceriler sırasıyla en çok bilişsel, sosyal-duygusal, motor, dil ve iletişim becerileridir. Çalışmalar hangi özel gereksinim grubunda hangi beceriye odaklanıldığı açısından da incelenmiştir. Tüm yetersizlik türlerinde beceri geliştirme amacıyla Kinect teknolojisinin kullanıldığı görülmektedir. İncelenen çalışmalarda, sıklık sırasına göre Kinect, VR, Nintendo ve OpenCV2-Psychopy2 V1.82-Python en çok kullanılan teknolojiler olmuştur. Bu teknolojiler yazılım, ekipman ve diğer hareket tabanlı teknolojilere entegre edilmiştir. Bir çalışmada ise hareket tabanlı bir teknoloji yerine hareket verilerini işlemek için bir görüntü işleme algoritmasının kullanıldığı görülmektedir. Özel eğitimde teknoloji destekli EL uygulamalarının kullanılmasının etkileri incelendiğinde, ağırlıklı olarak olumlu etkiler bulunmuştur. Ancak 4 çalışmada Kinect teknolojisinin neden olduğu teknik sorunlar, sistem kullanımında eğitim ihtiyacının neden olduğu sorunlar ve oturumlar arttıkça katılımcıların azalan motivasyonları gibi bazı zorluklardan bahsedilmiştir.

Tartışma, Sonuç ve Öneriler

Sistematik incelemenin sonucu, son yıllarda özel gereksinimli bireyler için EL çerçevesinde yürütülen çalışmaların sayısının arttığı yönündedir. İncelenen çalışmaların çoğu OSB'li bireyleri içermektedir. Çalışmalarda ele alınan değişkenler incelendiğinde, farklı engellilik türleri için en sık kullanılan değişken bilişsel beceriler olmuştur. Kosmas ve Zaphiris (2023), özel eğitimde EL uygulamalarına yönelik çalışmaların bilişsel, sosyal ve motor becerilerin geliştirilmesini amaçladığını belirtmiştir. İncelenen çalışmaların çoğu 10 veya daha az katılımcıyla yürütülmüştür. Ek olarak, çalışmalar çoğunlukla ilkokul öğrencileriyle yürütülmüştür. Zhong ve ark. (2023), teknoloji destekli EL ortamları üzerine yapılan çalışmaların ilkokul düzeyinde yoğunlaştığını belirtmişlerdir. Ayrıca, çalışmalardaki katılımcı sayısının genellikle düşük olduğunu vurgulamışlardır. Araştırmacılar, ortaokul ve lise düzeylerinde yapılan çalışmaların sınırlılığına dikkat çekmişler ve bu gruplarla EL uygulamalarının etkinliğinin hala belirsiz olduğunu vurgulamışlardır. Bu düzeydeki gruplara özel olarak odaklanan daha fazla çalışma yapılabilir.

İncelenen tüm çalışmalar katılımcılar için bir müdahale içeriyordu. Çalışmaların metodolojileri incelendiğinde, deneysel yöntemin sıklıkla kullanıldığı görülmektedir. Veri toplama yöntem ve teknikleri incelendiğinde en sık video ve ses kayıtları, görüşmeler, gözlemler, anketler, ölçek ve testler ile sistem kayıtlarının kullanıldığı görülmüştür. Malinverni ve Pares

(2014) yaptıkları incelemede değerlendirme yöntemlerinin öğrenme çıktıları üzerindeki belirli etkilerin derinlemesine anlaşılmasını sağlayabilmesi gerektiğini belirtmiştir. Zhong vd. (2023), bilginin kalıcılığı ve aktif katılımı sağlamak için çok boyutlu değerlendirmeler yapmanın önemine dikkat çekmiştir. Bu bağlamda, özel gereksinimli bireyler için teknoloji destekli EL ortamlarında kontrolün sisteme yerleştirildiği ve verilerin otomatik olarak kaydedildiği araçların kullanılma potansiyelinin incelenmesi önemlidir. Çalışmalarda ele alınan değişkenler incelendiğinde farklı engellilik türleri için en sık kullanılan değişken bilişsel beceriler olmuştur. Bunu motor beceriler ve sosyal-duygusal beceriler, dil ve iletişim becerileri ve öz bakım becerileri izlemektedir. Kosmas ve Zaphiris (2023), özel eğitimde EL uygulamalarına yönelik çalışmaların bilişsel, sosyal ve motor becerilerin geliştirilmesini amaçladığını belirtmişlerdir. Dolayısıyla mevcut çalışmada elde edilen bulgular diğer araştırmacıların bulgularıyla uyumludur. Öz bakım, özel gereksinimli bireylerin bağımsız bir günlük yaşam sürdürebilmeleri açısından önemli bir beceridir ve bu becerileri edinmelerini sağlamaya yönelik çabalar artırılabilir. Ayrıca, özel gereksinimli bireylerin edindikleri becerileri sürdürme, öğrenme sürecine katılmaya devam etme, öz yönetimi uygulama ve motive olma, akademik başarıya ulaşma ve beceri edinme yeteneklerini değerlendiren çalışmalar değerli olacaktır.

Bu sistematik inceleme, çalışmaların çoğunda Kinect teknolojisininin kullanıldığını ortaya koymuştur. Ancak çeşitli yazılım, ekipman ve teknolojilerin kullanıldığı çalışmalar da mevcuttur. Literatürde, EL ortamlarında çoğunlukla Kinect cihazları kullanılmıştır (Georgiou & Ioannou, 2019). Kinect'in uygun fiyatlı olması ve eğitimciler tarafından kullanım kolaylığı bu duruma etki etmiş olabilir. Bir çalışmada, Python tabanlı bir deneyde görüntü işleme algoritması kullanılmıştır. Bu teknolojiler bilişsel, duygusal ve psikomotor becerilerin gelişimine de katkıda bulunmaktadır (Georgiou & Ioannou, 2019). Ancak, bazı hareket tabanlı teknolojiler bazı durumlarda özel gereksinimli bireyler için yetersiz kalabilmektedir (Gürbulak & Esgin, 2016; Kowallik vd., 2021). Bu duruma alternatif olarak, kamera sistemleri ve görüntü işleme teknolojileri, karmaşık hareket verilerini daha geniş bir alanda işleme potansiyeline sahip olduğu için kullanılabilir. AR, VR ve yapay zeka (AI) gibi mevcut teknolojilerin hareket tabanlı teknolojilerle bütünleştirilmesi yoluyla özel gereksinimli bireyler için daha erişilebilir ve uyarlanabilir alternatif öğretim sistemleri geliştirilebilir. Özel eğitim öğretmenlerinin bu teknolojileri tanımaları önemlidir. EL ortamlarının bireyselleştirilmiş eğitim programlarına nasıl dahil edilebileceği konusunda araştırmalar yapılabilir.