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THE ENVIRONMENTAL DESIGN FACTORS ASSOCIATED WITH FUNCTIONAL INDEPENDENCE OF PEOPLE WITH INTELLECTUAL AND DEVELOPMENTAL DISABILITIES

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THE ENVIRONMENTAL DESIGN FACTORS ASSOCIATED WITH FUNCTIONAL INDEPENDENCE OF PEOPLE WITH INTELLECTUAL AND DEVELOPMENTAL DISABILITIES

A DISSERTATION APPROVED FOR THE
CHRISTOPHER C. GIBBS COLLEGE OF ARCHITECTURE

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This dissertation is committed to God (Proverbs 16:3). I dedicate it to my husband, my son, my daughter, my family, and my friends. I deeply appreciate your consistent support and devotion.

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This dissertation is based in part on the previously published article below. I have permission from my co-author and publisher to use the work in my dissertation. Copies of permissions present in Appendix A.

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ABSTRACT

Background: The increasing number of students are receiving special education services, and the majority of the students have identified as having cognitive challenges. Prior studies have explored the associations between the environment and students' behavior in the form of Evidence-based design (EBD) and evidence-based practice (EBP). A systematic review on EBD and EBP has identified 26 design strategies, which have the potentials to have positive impacts on students' behaviors. However, these environmental features' effectiveness has not been adequately addressed due to limited study design and small sample sizes. Efforts to creating inclusive environments for people with intellectual and developmental disabilities (IDD) have heavily relied on experts' opinions or limited evidence.

Purpose: The primary goal of the presented study is to analyze the relationship between the identified 26 environmental factors and students' adaptive and problem behaviors. Through empirical investigation, this study aims to prescribe these environmental attributes as evidence-based design guidelines for people with intellectual and developmental disabilities (DG-IDD).

Method: Data were collected through an online survey between February 17 and March 24, 2021. The survey consisted of the Environmental Evaluation (EE), Performance Measure (PM), and the Brief Problem Monitor (BPM), which measured environmental attributes, adaptive behavior, and problem behavior, respectively. The collected 168 survey responses were used for factor analyses, multiple imputations, and regression analyses.

Results: Factor analyses categorized the DG-IDD items into four components: affordance, restoration, control, and coherence. Results of multiple regression analyses supported that a set of the DG-IDD positively predict students' adaptive behaviors when their disability levels were controlled (the Environ-Adaptive Behavior model; $F(2, 90.13) = 25.363$, $R^2 = 0.278$, $p = .000$).

Specifically, restorative features were associated with conceptual/practical skills ($F(2, 383.04) = 31.77$, $R^2 = 0.301$, $p = .000$), and the controllable characteristics were relevant to social skills ($F(2, 37.77) = 12.068$, $R^2 = 0.181$, $p = .000$). The regression analyses did not support that DG-IDD inversely predicted problem behaviors (the Environ-Problem Behavior model; $F(1, 43.42) = 3.244$, $R^2 = 0.034$, $p = .079$). The collected data did not support any associations between the design features and internalizing or externalizing problem behaviors. However, correlation analysis displayed the negative relationship between the DG-IDD and the problem behaviors ($R = -0.191$, $p = 0.029$). Furthermore, controllable features were associated with reduced attentional problem behaviors controlling students' ages and disability levels ($F(3, 68.15) = 5.195$, $R^2 = 0.110$, $p = .003$).

Conclusion: The preliminary analysis indicated that educational settings that have the DG-IDD items are associated with more frequent occurrence of adaptive behaviors while fewer problem behaviors of students with IDD.

Keywords: environmental design, adaptive behavior, intellectual and developmental disabilities, evidence-based design, autism spectrum disorder

Introduction

Background and Significance

The prevalence of intellectual and developmental disabilities (IDD) among the United States and South Korea population has been reported. According to the National Center for Education Statistics (NCES), the number of students who receive special education services under the Individuals with Disabilities Education Act (IDEA) had been increased from 6,401 thousands to 7,134 thousands from 2011 to 2019 (de Brey et al., 2021). The number is predicted to grow reflecting the trend (Anderson et al., 2019). Not only the U.S. population, but also South Korea census data has shown the increasing number of people with IDD. The Korean Ministry of Education (2020) reported that students who receive special education had increased from 82,665 to 92,958 in the same period between 2011 and 2019. Among this population, 78% and 90.7% of the students have been identified as having cognitive challenges in the United States and South Korea, respectively. The prevalence of people with IDD could be a threat to social sustainability since the census data indicates that those who need support are increasing. When the demand of people with a high dependency level exceeds the supply of caregivers, social sustainability will be hardly achievable.

To address these issues, there have been efforts to creating inclusive, enabling environments, in which people with IDD can be as independent as possible. As the social model of disability has reconceptualized 'being disabled' as an experienced phenomenon caused by socially placed barriers, removing any disabling environments has become a social responsibility. Furthermore, the philosophy of universal design, known as "the design of products, buildings, or environments to be usable to the greatest extent possible by people of all ages and abilities," has contributed to placing people with disabilities on an equal field with the

non-disabled people (Story et al., 1998, p. 2). Additionally, its concept has subscribed to the ideas of barrier-free, accessible design that focuses on people with disabilities, as well as a broader paradigm of inclusive, enabling design that considers all users regardless of age or ability (Audirac, 2008).

Along with the philosophical shifts, there have been attempts to legislate social responsibility to define a baseline for minimum accessibility, ensuring the built environment not to discriminate against people with disabilities: Architectural Barriers Act in 1968, Americans with Disabilities Act (ADA) of 1990, and ADA amendments act of 2008. Greater assurance has been achieved among people with physical disabilities for better access to built environments; however, there has been relatively little attention to the accessibility needs of people with IDD. (Yalon-Chamovitz, 2009; Salmi, 2007). The Olmstead decision 1999 has been particularly instrumental in determining intellectual disability as a form of disability protected under Title II of the ADA and bringing the population to community integration. However, researchers have still addressed the lack of consideration of IDD in the 2010 ADA Standards for Accessible Design (Trescher, 2018; Sherman & Sherman, 2013; Yalon-Chamovitz, 2009; Salmi, 2007).

The lack of consideration for people with IDD is understandable because the environmental barriers that this population is experiencing are abstract and invisible. People with IDD face cognitive challenges in performing everyday lives. Specifically, they need support with adaptive behaviors, such as skills to understand abstract concepts and ideas (e.g. language, literacy, space, etc.) (Armstrong & Morrow, 2010; Possin, 2010; Wang & Bellugi, 1993), hands-on skills (e.g. activities of daily living, wayfinding, etc.) (Guderian et al., 2015; Just et al., 2007), and social skills (e.g. interpersonal, communication, etc.) (Beaver, 2011; Humphreys, 2008; Lee et al., 2007). Furthermore, people with IDD are vulnerable to problem behaviors, including

internalizing problems (e.g. anxiety, depression, phobia, etc.) (Einfeld et al., 2011; Hartley & Maclean, 2008; Dekker & Koot, 2003;), and externalizing problems (e.g. self-injurious, stereotypic, and aggressive/destructive behaviors, etc.) (Samson et al., 2015; Lande et al., 2009).

Such needs of people with IDD have been addressed in evidence-based (EB) approaches; specifically, evidence-based practice (EBP) in special education and evidence-based design (EBD) in the environmental design field. In special education, empirical evidence of EBP has examined the effectiveness of the physical environment on adaptive behaviors or problem behaviors. The environmental features associated with students behaviors were: spatial sequencing (Hume & Odom, 2007; Zazzi & Faragher, 2018); environmental cues (Courbois et al., 2013; Pierce et al., 2013; Hume & Odom, 2007); non-text component (Courbois et al., 2013; Hume & Odom, 2007); gross-motor areas (Yuill et al., 2007); extended personal space (Zazzi & Faragher, 2018); low arousal environments (Kinnealey et al., 2012); and multisensory environment (Cermak et al., 2015; Hill et al., 2012; Lotan & Gold, 2009; Slevin & Mcclelland, 1999). However, most EBP studies employed a single-subject experimental design (SSED), which involves a small sample size. Besides, the majority of the identified strategies have not been supported by a sufficient number of SSED. Since prior studies were limited to particular study designs with limited sample size, future study is required to further validate and generalize the findings.

In the environmental design field, EBD studies have contributed to identifying a variety of design strategies. Twenty six design strategies for people with IDD were mentioned in twenty EBD studies (Ahrentzen & Steele, 2009; Beaver, 2011; Castell, 2012; Deochand et al., 2015; K. Gaines et al., 2016; K. S. Gaines et al., 2014; Khare & Mullick, 2009; Lowe et al., 2014; Marchi, 2013; McAllister & Maguire, 2012; Mostafa, 2008, 2010, 2014; Nagib & Williams, 2017; Salmi,

2007; Sánchez et al., 2011; Scott, 2009; Steele & Ahrentzen, 2015; Vogel, 2008; Woodcock et al., 2007). However, there has been a limited number of experimental (Mostafa, 2008) and analytical observational studies (Khare & Mullick, 2009). The majority of EBD studies have been descriptive observations, which methods include surveys, qualitative interviews, or case studies; or even lower evidence level of experts' opinion or reflective experience. These types of data can get easily biased and have limitations in internal validity. Thus, the identified design features supported by such relatively weak evidence require future studies showing repeated findings (higher reliability) or testing them through inferential statistical analysis.

Purpose of the Study

Therefore, the identified design strategies in EBP and EBD need to be further examined regarding their associations with adaptive behaviors or problem behaviors of people with IDD. The presented study aims to test the association between the physical environment and behaviors of people with IDD. Specifically, this study focuses on 26 environmental attributes as independent variables, which have been identified in the literature, but have not been supported with sufficient evidence. The two dependent variables are adaptive and problem behaviors that people with IDD could potentially exhibit in their learning environments. By testing the associations between the enabling environmental features and adaptive or problem behaviors, the presented study seeks to prescribe evidence-based design guidelines for people with intellectual and development disabilities (DG-IDD).

To achieve this goal, the presented study uses Khare & Mullick's (2009) four stages to develop design guidelines:

- Stage 1. Identifying environmental design considerations in regard to the educational and behavioral aspects

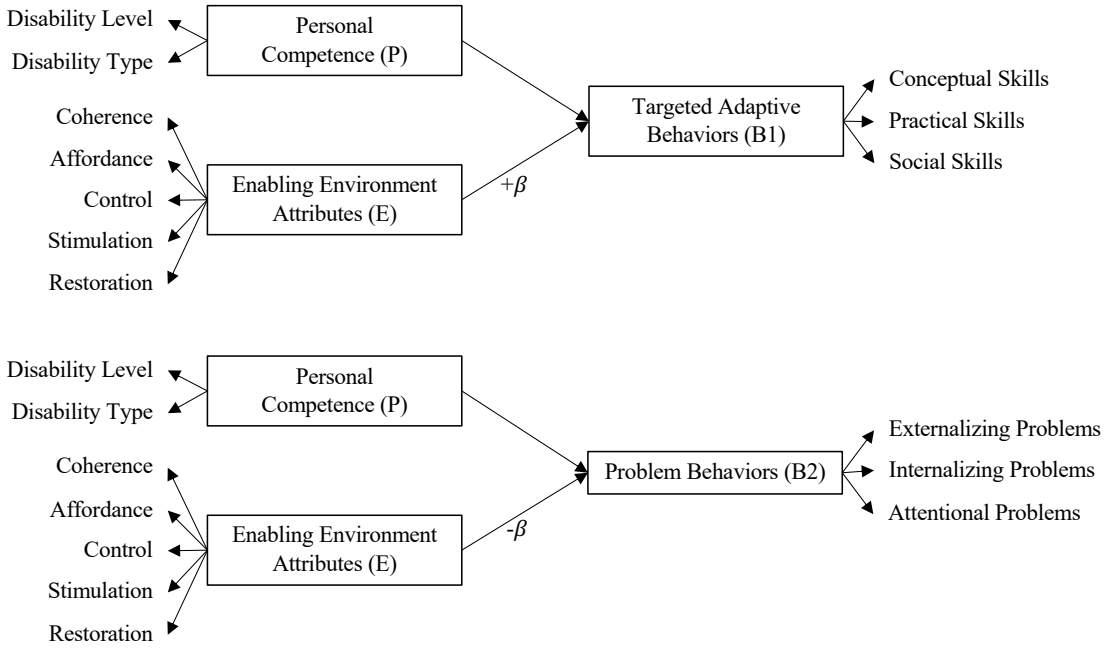
- Stage 2. Defining design parameters that have a connection to the population
- Stage 3. Developing measurement scale and testing design parameters
- Stage 4. Prescribing evidence-based design guidelines

Research Questions and Corresponding Hypotheses

Specifically, in stage 3, the regression analysis aims to test the hypotheses illustrated in Figure 1 followed by the statements.

Figure 1

Conceptual Model



Question #1: To what extent do a set of design factors predict adaptive behaviors of people with intellectual and developmental disabilities (IDD)?

Hypothesis #1: Among people with IDD, a set of enabling design features will positively predict their adaptive behaviors when personal factors are controlled.

Question #2: To what extent do a set of design factors predict problem behaviors of people with intellectual and developmental disabilities (IDD)?

Hypothesis #2: Among people with IDD, a set of enabling design features will inversely predict their problem behaviors when personal factors are controlled.

Literature Review

Impact of Environment on People with IDD

Prevalence of People with IDD

Among U.S. population, the prevalence of intellectual and developmental disability (IDD) has been reported. According to the data from 2009 – 2011 to 2015 – 2017, there had been significant increases in any developmental disability overall (16.2% – 17.8%, $p<.001$) (Zablotsky et al., 2019). Specifically, intellectual disability has increased from 0.9% to 1.2% ($p<.05$), and autism spectrum disorders from 1.1% to 2.5% ($p<.001$) (Zablotsky et al., 2019).

More recently, the National Center for Education Statistics (NCES) has reported that students who receive special education services under the Individuals with Disabilities Education Act (IDEA) comprise 14% of the total public-school enrollment between 2018 – 2019 (de Brey et al., 2021). Among this population, 78% of students have been identified as having cognitive challenges; specifically, Autism (10.7%), developmental delay (6.7%), intellectual disabilities (6.2%), multiple disabilities (1.9%), learning disabilities (33.2%), and speech or language impairment (19.3%) (de Brey et al., 2021). The number of total students receiving special education has been increased from 6,401 thousands to 7,134 thousands from 2011 to 2019. The number is predicted to grow reflecting the trend (Anderson et al., 2019).

Not only the U.S. population, but also South Korea census data has shown the increasing number of people with IDD. According to the Korean Ministry of Education (2020), students who receive special education have increased from 82,665 to 92,958 in the same period between 2011 and 2019. In 2020, 95,420 students, approximately 1.6% of the total school enrollment, have received special education. Among those who enrolled in special education, 90.7% were relevant to cognitive challenges, including intellectual disability (53.1%), developmental

disability (10.4%), autism spectrum disorder (14.6%), developmental delay (8.8%), leaning disability (1.3%), and speech or language impairment (2.5%).

The prevalence of people with IDD could be a threat to social sustainability. Social sustainability occurs when individuals' independence and well-being is persistently achievable within social system and environments. However, the census data indicates that people who need support are increasing. When the demand of those with a high dependency level exceeds the supply of caregivers, social sustainability is hardly achievable. Furthermore, people with IDD are vulnerable to developing mental, behavioral, and learning problems. The presence of these problems also implies people with IDD are likely to experience socio-economic disadvantages, poor quality of life, and exclusion from society (Nouwens et al., 2017). Thus, the environmental design should be conscious of the population with IDD to prevent these risks.

Unique Challenges of People with IDD

The challenges of people with intellectual and developmental disabilities (IDD) can be explained in terms of adaptive and problem behaviors. Adaptive behavior is a necessary skill to function independently in daily life, meanwhile, problem behavior refers to behaviors that impede one's independent living. Studies have shown that people with IDD have challenges in performing adaptive behaviors and dealing with problem behaviors. In the following section, specific challenges of people with IDD are explored followed by environmental considerations to support with their challenges regarding adaptive and problem behaviors.

Support with Adaptive Behavior

Adaptive behavior is one of the dual criteria that define intellectual disability. According to the American Association on Intellectual and Developmental Disabilities (AAIDD), intellectual disability is defined as "a disability characterized by significant limitations in both

intellectual functioning and in *adaptive behavior*, which covers many everyday social and practical skills [Emphasis added]" (Schalock et al., 2021, 2010). Intellectual functioning regards mental capacity such as learning, reasoning, and problem-solving, and other factors that are measured by an intelligence quotient (IQ). Adaptive behavior refers to the skills to function independently in one's environment (Tassé et al., 2012). According to the Diagnostic Adaptive Behavior Scale (DABS), adaptive behaviors consist of conceptual (e.g. language, number, money, and time), practical (e.g. activities of daily living, healthcare, and safety), and social skills (e.g. interpersonal skills, social responsibility, and self-esteem) (Tassé et al., 2017, 2012).

Conceptual skills. Conceptual skills refer to the abilities that deal with abstract concepts and ideas (Tassé et al., 2017). With specific regards to the population's distinctive cognitive mechanism when interacting with their environment, the examples of conceptual skills include understanding spatial context, and language/literacy.

People with IDD have been linked to a deficit in organizing different spatial information into a three-dimensional integrated mental map (Wang & Bellugi, 1993; Possin, 2010). The environment is experienced by spatial cognition, such as spatial representation, memory, and reasoning (Denis & Michel, 2017). The spatial knowledge acquired through this experience is crucial because it is the basis of practical behaviors that are habitually used to perform daily activities. However, the difference in brain function makes people with IDD perceive their environment differently from people without disabilities. Often, the increased activation in early visual brain regions (occipital lobe) enhances local processing of details, while reduced activation in the frontal and parietal regions hinders global processing of context (Koshino et al., 2005). Accordingly, this population is highly likely to face challenges in organizing and understanding their environment as a whole. The environmental design needs to be conscious of

the limited ability to integrate abstract spatial information. Predictable and cohesive environments could lead to a reduced opportunity for disorientation, memory loss, and wandering.

People with IDD are relatively at a lower level in language and literacy (Kirsch, Jungeblut, Jenkins, & Kolstad, 1993; Tuffrey-Wijne, & McEnhill, 2008; Yalon-Chamovitz, 2009). When it comes to processing language comprehension, people with IDD show difficulty integrating semantic information while relying on single-word semantic processing. This behavioral pattern is explained by cerebella abnormality as well as a model of reduced long-range connectivity (Armstrong & Morrow, 2010). The environment might be chaotic to people with IDD if messages are primarily delivered in written texts. Any text component in their environments should be provided at their reading level. When it comes to processing non-text cues, people with IDD demand concrete visual support because of their challenges in interpreting abstract symbols. Environmental cues that consider such perceptual pattern of people with IDD will prevent this population from misunderstanding the information and being excluded from society.

Practical skills. Practical skills are hands-on skills necessary to perform everyday lives, such as conducting activities of daily living (ADLs) and navigating the environment (Tassé et al., 2017). People with IDD have difficulty performing independent living skills. They require more energy and time in problem-solving, adapting to change, and planning. The reduced connectivity in the executive brain suggests the presence of such challenges (Just et al., 2007). Moreover, people with IDD often show superior performance in certain repetitive tasks but challenges in higher-order processing in completing complex tasks. Considering such particular perceptual-cognitive style, support needs for daily living skills include, but not limited to, personal care (e.g.

dressing, grooming, and hygiene), household maintenance (e.g. laundry, cleaning, and safety), nutrition (e.g. food preparation, cooking, and eating), financial management, personal organization (e.g. materials and time), and community access. Their environment should be provided in a way to assist everyday routine efficiently.

A navigational challenge is another prominent experience among people with IDD. A navigating function is a critical factor to assist independent functioning. The distinctive neurobiological features among people with IDD, such as the affected hippocampus and cerebral mechanism, have predicted the population's challenges in spatial memory and navigation (Guderian et al., 2015). People with IDD tend to rely on viewer-centered spatial coding (egocentric) rather than object-to-object relational coding (allocentric). Such navigational bias among people with IDD suggests that an adequate environmental support is necessary to achieve the population's autonomous mobility.

Social skills. Social skills are defined as skills relevant to interaction with others (Tassé et al., 2017). Limited verbal skills in coupled with general cognitive functioning contribute to challenges in social interaction and communication. Neurocognitive features also explain the difficulty in social skills. The temporal lobe, which is responsible for visual and sound processing, is often affected among people with IDD (Lee et al., 2007). As a result, people with IDD use alternative face voice processing strategies and show their preference toward non-social information. Studies have also shown that people with IDD require peculiar proxemics (Humphreys, 2008; Beaver, 2011). Such behavioral patterns and preferences should be addressed when designing social areas for people with IDD to promote their participation and engagement.

Support with Problem Behavior

On the other hand, problem behavior, also called maladaptive behavior, is an opposite concept from adaptive behavior. Problem behavior refers to a behavior that interferes with independence for daily activities. According to Achenbach's (2009) research, problem behaviors are categorized into internalizing and externalizing conditions.

Internalizing Problems. Internalizing problems reflect an internally distorted or inconsistent emotional state that interferes with the ability to function properly. Examples of internalizing problems that people with IDD often exhibit include anxiety, depression, and social withdrawal (Lande et al., 2009). People with IDD have reported more frequent and severe stress, and furthermore, they have shown difficulty adaptively coping with stress (Hartley & Maclean, 2008). People with IDD are at risk for deficits in emotion regulation, which leads to an increase in the likelihood of developing psychological disorders (Rodas et al., 2017). It is reported that possibilities are higher among children with IDD to meet DSM-IV criteria for psychiatric disorders compared to typically developing children (Dekker & Koot, 2003; Einfeld et al., 2011). Specifically, DSM-IV disorders include anxiety disorder (e.g. social phobia, separation anxiety, etc.), mood disorder (e.g. major depressive disorder, dysthymic disorder, etc.), and disruptive disorders (e.g. attention deficit hyperactivity disorder (ADHD), hyperactive-impulsive type, etc.). To ensure psychological well-being, environmental design should be conscious of the vulnerability that people with IDD exhibit in dealing with their emotional state.

Externalizing Problems. Externalizing problems reflect externally observable discomfort and conflict as a form of negative reaction to the external environment. Problem behaviors occur among people with IDD in a form of a tantrum, conflict with others, violation of social norms, self-injurious, stereotypic, and aggressive/destructive behaviors (Lande et al., 2009). The factors

that give rise to problem behaviors are not well reported; however, it has been suggested that the problem behaviors are associated with increased negative emotions (Samson et al., 2015). Another factor that is associated with external problem behaviors is Sensory Integration Dysfunction (SID). Challenges in sensory information processing are well reported, especially among people with Autism Spectrum Disorders (ASD). SID is a neurological disorder that involves abnormal responses to sensory stimuli in a form of either hyper or hyposensitivity (Marchi, 2013). There has been no reliable evidence of the brain mechanisms underlying SID, but it is commonly explained by a decreased structural brain connectivity in sensory regions (Armstrong & Morrow, 2010). People with SID may be extremely sensitive to or underwhelmed by visual, tactile, auditory, olfactory, vestibular senses. They tend to respond to these stimuli as negative reactions, such as stereotyped, repetitive, self-stimulatory behaviors (Nagib & Williams, 2017). Thus, external problem behaviors should be addressed when designing an environment for people with IDD as they can cause serious safety issues. The design should consider the ways to prevent the occurrence of problem behaviors or the therapeutic strategies to mitigate or deal with problem behaviors when they are externalized.

History of Creating Environments for People with IDD

The previous sections have discussed the prevalence of people with IDD followed by their unique needs in interacting with their environments. As the environmental design is necessary to consider the population's unique needs, this section discusses how conceptual and practical efforts have been made historically to embrace people with IDD.

Reconceptualization of Disability and Environment. The reconceptualization of the term 'disability' and its relation to environments dates back to the beginning of the barrier-free movement in the 1950s and the disability rights movement in the late 1960s. People with

disabilities started to redefine themselves, with the active goal of ensuring their inclusion into diverse aspects of society. They initiated activities that ensure equal opportunity and eliminate any form of discrimination on the basis of disability. The movements influenced philosophical shifts, for instance, the emergence of the social model of disability and the universal design concept.

The social model of disability. There have been two frameworks that conceptualize disability: the medical and social models of disability. The medical model of disability presumes that disability is a characteristic that needs to be cured or overcome; meanwhile, the social model of disability assumes disability as a phenomenon that is socially constructed (UPLAS, 1976).

The social model of disability has reconceptualized disability as an outcome of the interaction between the person and the environment, rejecting the medical model that regards disability as a part of a person's impairment or difference (Lawton & Nahemow, 1973; Brandt & Pope,1997; World Health Organization, 2001; Putnam, 2002). The term 'disability' was defined distinctively from physical impairments by the Union of Physically Impaired Against Segregation (UPIAS) (UPLAS, 1976). Physical impairment refers to "loss and/or abnormality of a mental, emotional, physiological, or anatomical structure or function," while disability is defined as "inability or limitation in performing socially defined activities and roles expected of individuals within a social and physical environment" (Brandt & Pope, 1997, p. 6). In other words, from the theoretical stance of the social model, disability is not a constraint caused by personal attribute or inherent impairments, rather being disabled is an experienced phenomenon caused by barriers that is socially placed in the given environment. In this context, challenges that a person with disabilities encounters are not associated with their physical or mental differences, limitations, or deficits, but are related to social disadvantages and exclusions.

Toward non-disabled lifestyles, it is not individuals' responsibility to overcome or cure their impairments with help from medical and rehabilitation professionals. Rather, the responsibility shifts to societies' responsibility to remove any disabling environments.

In the same manner as the social model in the disability sector, the architectural model of disability appeared in an architectural field. In the architectural model of disability, architecturally abled people are those who can conveniently use the building in their environment. However, the architectural disability model assumes that even non-disabled people can be architecturally disabled on account of building features (Goldsmith, 2007). For example, people with a stroller could be temporarily disabled in using stairs. The architectural model premises architect as a preventative therapist. By providing enabling environments, architects can prevent people from being disabled in a built environment.

Universal Design. Adapting social and architectural models of disability justifies socially created barriers and discriminations to be removed. Both models have been a plausible foundation in developing the concept of universal design. The generally known definition of universal design is "the design of products, buildings, or environments to be usable to the greatest extent possible by people of all ages and abilities" (Story et al., 1998, p.2). The philosophy of universal design subscribes to the ideas of barrier-free, accessible design that focuses on people with disabilities, as well as a broader paradigm of inclusive, enabling design that considers all users regardless of age or ability (Audirac, 2008).

- Barrier-free design: Designing for removing physical barriers from the built environment for people with disabilities (Audirac, 2008)
- Accessible design: Designing for equal opportunity of access for people with disabilities (Audirac, 2008)

- Inclusive design: Designing of mainstream products and/or services that is accessible to, and usable by, as many people as reasonably possible … without the need for special adaptation or specialized design (BSI, 2005)
- Enabling design: Designing for enabling people to function at their highest level possible (Audirac, 2008)

Practices and Legislations. The models and philosophies that reconceptualize disability and environment have increased the potential for creating better environments and increasing the quality of life for a wide range of individuals. As a result of the shift in paradigm, society has started to put people with disabilities on an equal field with the non-disabled people. Also, the needs for special accommodation and assistive devices have been reduced (Steinfeld & Maisel, 2012). More importantly, the reconceptualization of disabilities has contributed to legislating social responsibility to define a baseline for minimum accessibility. The legislative support that has made the built environment not discriminate against people with disabilities include the Architectural Barriers Act of 1968, the Americans with Disabilities Act (ADA) of 1990, and the ADA amendments act of 2008. Along with such accessibility laws, the Olmstead decision 1999 has been particularly instrumental in determining intellectual disability as a form of disability protected under Title II of the ADA and bringing the population to community integration. The landmark efforts are presented in chronological order in this section.

Architectural Barriers Act of 1968. The Barrier-free movement in the 1950s caused changes in public policies and design practices. In 1961, the American National Standards Institute (ANSI) published the first accessibility standard and attempted to implement it into federal guidelines (Holmes-Seidle, 2012). Such effort led to the Architectural Barriers Act of 1968, which was the first U.S. federal law that mandated accessibility. This act ensured people

with disabilities be accessible to the built environments that were designed, built, or leased by federal agencies.

Americans with Disabilities Act (ADA) of 1990. ADA was legislated in 1990 as a civil rights law that prohibits discrimination and ensures equal opportunities for people with disabilities. ADA protects people with disabilities in diverse aspects of public lives, including employment, government services, public accommodations, transportation, and telecommunications (Department of Justice, n.d.). Additionally, the ADA standards for Accessible Design was published in 1991, which was remarkable progress in defining an accessibility baseline for the built environment.

Olmstead decision. Olmstead v. L.C., U.S. 581 (1999), is a United States Supreme Court case that reinforced the right of people with IDD to live in the community. The Supreme Court held that Title II's integration mandate prohibits the unjustified segregation of individuals with IDD and requires public entities to be reasonably modified when necessary to avoid discrimination. Olmstead contributed to placing people with intellectual disabilities in the most integrated setting, in which people with disabilities are able to interact with non-disabled people to the fullest extent possible (Olmstead: Community Integration for Everyone, n.d.). The Olmstead case played a significant role in determining that intellectual and developmental disabilities are a form of disability under Title II of the ADA.

ADA amendment act (ADAAA) of 2008. Amendments to the ADA in 2008 clarified who is covered by the law. ADAAA covers a wide range of disabilities, from physical conditions affecting mobility, sight, and hearing, to cognitive abilities. The update of the 2010 ADA Standards for Accessible Design mostly retained the original provisions in 1991, but some

significant differences were made to ensure better accessibility for people with diverse disabilities (Americans With Disabilities Act of 1990, As Amended, 2009).

However, the limitation has been addressed about the lack of consideration of intellectual and developmental disabilities in the 2010 ADA Standards for Accessible Design (Trescher, 2018; Sherman & Sherman, 2013; Yalon-Chamovitz, 2009; Salmi, 2007). Invisible barriers that people with intellectual disabilities face have not been adequately addressed. Accordingly, people with intellectual disabilities still encounter challenges in accessing public amenities. When it comes to signage guidelines, for example, ADA provides instructions on size, type, finish, contrast, and placement (ADA Standards for Accessible Design, n.d.). However, designs that impede the performance of people with intellectual disabilities still need to be adequately addressed, such as building layouts that are confusing and disorienting, and visual cues that are not easy to follow, and sensory environment that triggers arousal.

Systematic Review of Associations Between Environment and Behavior of People with IDD

Research on Creating Environments for People with IDD

As discussed in the previous section, philosophical shifts and legislative supports have contributed to creating inclusive environments for people with disabilities. Greater assurance has been achieved among people with physical disabilities for better access to built environments; however, there has been relatively little impact on people with IDD. Rather, the accessible environments for people with IDD have been addressed in evidence-based (EB) approaches, which seek "the conscientious, explicit, and judicious use of current best evidence in making decisions"(Sackett et al., 1996). The EB approach was originated from evidence-based medicine (EBM) in the 1990s and expanded to other fields, such as nursing, social sciences, and education. With the specific scope on people with IDD and their environments, the presented study reviews

evidence-based practice (EBP) in special education and evidence-based design (EBD) in the environmental design field.

Evidence-Based Practice (EBP) for People with IDD: Special Education

Evidence-based approach has been morphed into special education field as evidence-based practice (EBP). EBP refers to "research-based or empirically supported programs, practices, or strategies intended to increase skills, competencies, or outcomes of children, youth, and/or families in targeted areas" (Stoiber et al., 2016, p.42).

Researchers, practitioners, policymakers have collaborated in identifying scientific knowledge to inform intervention practices in special education. Such efforts have played important role in accumulating a growing number of resources and improving intervention effectiveness and outcomes. EBP for individuals with disabilities was recently added as a part of What Works Clearinghouse (WWC), which is regarded as the most comprehensive source on EBPs (WWC, 2011). However, records of only select disability groups have been included in WWC (e.g. students with learning disabilities, emotional and behavioral disorders, etc.), but reviews for people with IDD have been absent.

Instead, several groups have provided guidelines and criteria for reviewing the effectiveness of intervention efforts for people with IDD. As an example, Stoiber et al. (2016) suggested four categories of criteria to be examined in the review of intervention studies: (1) scientific basics that regard the empirical/theoretical basis, general design qualities, and statistical treatment of the intervention, (2) key component features that consider the internal and construct validity of the research study, (3) clinical utility that regards a range of acceptability and generalizability aspect of an intervention, and (4) feasibility and cost effectiveness which regard the fidelity and usefulness of the intervention within the applied setting. Stoiber et al.

(2016) also established a framework for intervention research quality assessment: (1) strong support – at least two high-quality experimental or quasi-experimental group studies, (2) moderate support – one high-quality study or several studies with some limitations, and (3) low or no support – several studies with severe limitations or no direct research evidence.

In the same manner with EBM, the EBP also considers randomized controlled trials (RCT) as the best methodology. It is important to note that a majority of experimental research in EBP has been single-subject experimental design (SSED), which involves a single case or a small number of participants approximately between 2 and 8. The prevalence of SSED suggests weak external validity which requires replication to determine if the results are worthy of generalization. For example, Odom et al. (2010) considered SSED as EBP if it met the following criteria: five high-quality SSED conducted by three different investigators/research groups, or three high-quality SSED studies in combination with one high-quality RCT or quasi-experimental group design study

Evidence-Based Design (EBD) for People with IDD: Environmental Design

EB approaches were evolved into the evidence-based design (EBD) in the planning and design field. EBD is defined as "the deliberate attempt to base building decisions on the best available research evidence with the goal of improving outcomes and of continuing to monitor the success or failure for subsequent decision-making" (Malkin, 2008, p. 2). In the earlier stage, healthcare designers have been leading the EBD charge because EBD is originated from evidence-based medicine (EBM). More recently, there has been a growing trend toward evidence-based design (EBD), covering other healthcare settings, such as long-term care facilities, independent living homes, and retirement community, as well as other types of buildings, embracing the working, learning, living, and playing environments.

The triumph of EBD is witnessed through a variety of programs and publications, such as the Evidence-based Design Accreditation and Certification (EDAC) of the Center for Health Design (CHD), the Health Environments Research & Design Journals (HERD), Healthcare Design (HCD) magazine, and the Environmental Design Research Association (EDRA) conferences. To support this growing body of knowledge, the Center for Health Design (CHD) introduced the eight-step model for evidence-based research: defining EBD goals & objectives, finding sources for relevant evidence, creating and innovating EBD concepts, developing hypotheses, collecting baseline performance measure, monitoring design and construction, and measuring post-occupancy results (The Center for Health Design, 2015). Some researchers have set selection criteria in their EBD literature reviews (Viets, 2009; Ulrich et al., 2008): peer-reviewed publications, empirically-based studies, quantitative design, triangulated qualitative design, and traditional authority with caution. However, there has not been an established agenda for selecting, organizing, evaluating the quality evidence for EBD.

Researchers have addressed the insufficient experimental studies in EBD (Steele & Ahrentzen, 2015; Viets, 2009; Ulrich et al., 2008). Steel and Ahrentzen (2015) stated that reliable sources on this topic, with double-blind, randomized experiments, published in peer-reviewed journals, were rare in environmental design research. The lack of experimental studies in this field is understandable because most changes in the physical environment are not only costly, but also involves interwoven factors. Specifically, an environmental change of one feature often simultaneously alters the other environmental factors. Such constraint makes experimental studies hard to control the unexpected variables and assess the independent effect of one factor. Accordingly, relatively weak evidence is prevalent in EBD, such as experts' reflective experience/opinion, post-occupancy evaluations of a single case study, and non-

experimental studies. The review of such studies requires cautious interpretation and examination to reduce potential bias and limitations.

Systematic Review Approach

Procedure. The Effective Public Health Practice Project's (EPHPP) protocol guided the methodology of the presented systematic review process. The EPHPP protocol considered seven stages: question formulation, searching and retrieving the literature, establishing relevance criteria, study quality assessment, data extraction and synthesis, written report, and dissemination (Thomas et al., 2004). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocols 2009 checklist was used for reporting the current review (Moher et al., 2009).

Search Strategy. Keywords searches were conducted. Keywords were selected considering this study's population and intervention: ((intellectual disabilit*) OR (Autism)) AND environment* AND design. The terms were searched in EBSCO research databases, enabling the simultaneous search of multiple database: ERIC, ProQuest, PsycINFO, MEDLINE, CINAHL, Consumer Health Complete (EBSCOhost), Psychology and Behavioral Sciences Collection. The search was restricted to full-text, peer-reviewed studies published between 1990 and 2020. Among the selected articles, a bibliography and hand search were also conducted.

Inclusion Criteria and Screening. The abstract and title of the identified studies were screened by the following predetermined inclusion criteria: (a) participant: people with intellectual disabilities and/or autism spectrum disorders (ASD); or caregivers, educators, architects working for the population, (b) intervention: environmental intervention or environmental design strategies, (c) outcomes: adaptive behaviors (conceptual, practical, and social skills) and problem behaviors (internalizing, externalizing, and attentional problems)

exhibited in educational settings, (d) context: the interior of the learning and/or living environment. Any types of study design were considered, reflecting the lack of experimental studies in environmental design studies (Steele & Ahrentzen, 2015; Ulrich et al., 2008). Once the initial screening of abstracts and titles was completed, the full texts of the selected studies were screened against the same eligibility criteria.

Study Classification and Quality Assessment. Different quality-assessment tools were used according to the research design. To classify the research design, the seven levels of evidence were used (Ackley et al., 2008). The "Quality Assessment Tool for Quantitative Studies" was used to critically appraise the selected quantitative studies (EPHPP; https://merst.ca/tools/). The CASP qualitative studies checklist was used to assess qualitative research, and the CASP systematic review checklist was used for literature review studies (CASP; https://casp-uk.net/casp-tools-checklists/).

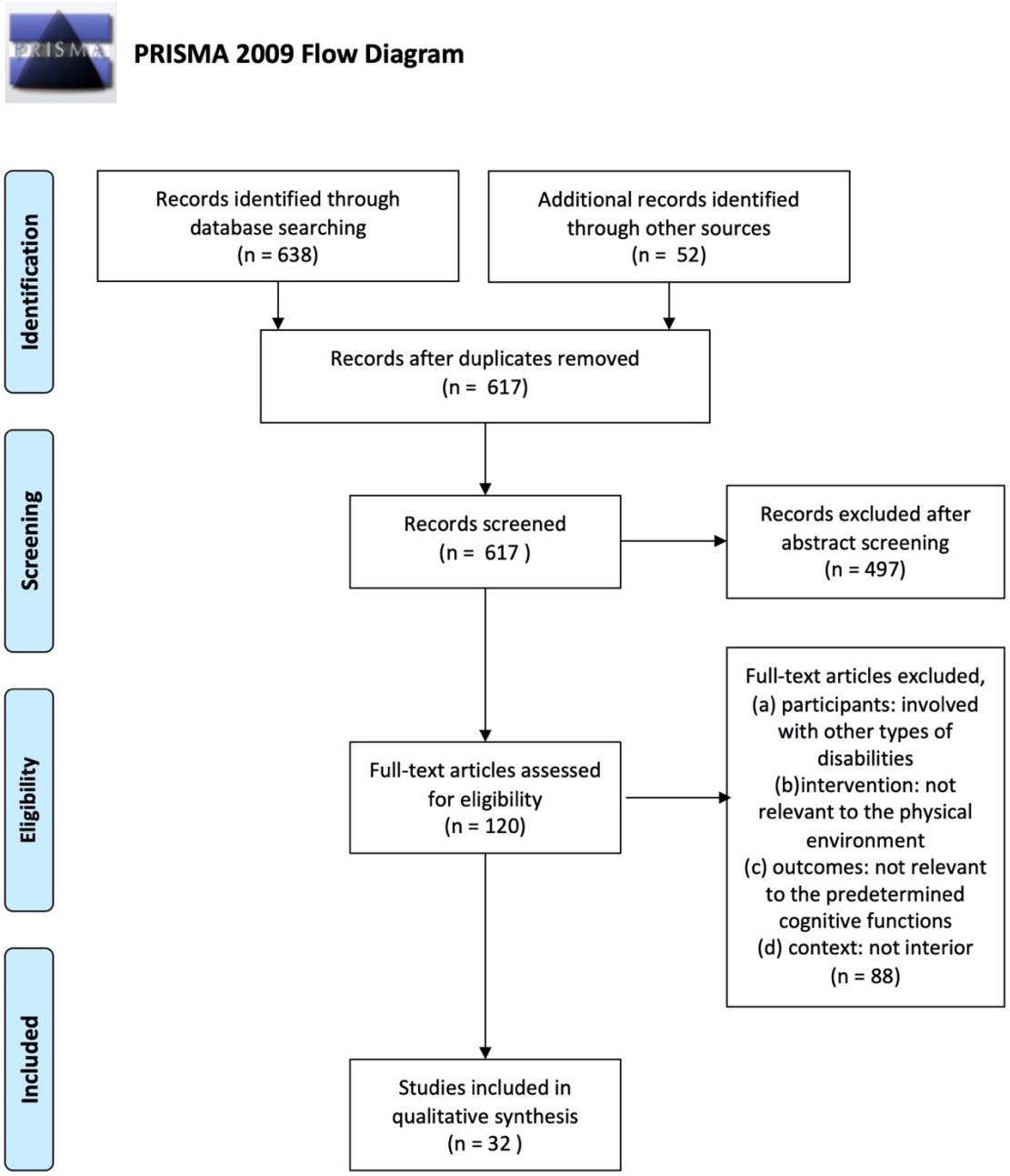
Data Extraction and Synthesis (Coding). Data were extracted by using the matrix that includes information on study design, participants (i.e. description, number, and age), comparison, independent variables, and dependent variables. The results are also synthesized according to the design strategies in a relation to the outcome functions. Following the directed content analysis process (Assarroudi et al., 2018), design strategies were coded and categorized according to the five domains: coherence, affordance, control, stimulation, and restoration. Meta-analysis was not conducted because quantitative data was available for a small number of studies. Eight out of ten experimental studies employed the single-subject experimental design (SSED), in which the number of participants was between one and eight. Due to the limited number of participants, quantitative synthesis was not used, instead, the results were summarized narratively.

Systematic Review Results

The records identified through database search were 638, and additional records identified through bibliography and hand search were 52. The titles and abstracts of 617 records were screened after removing duplicates, and 120 records remained. Full text was assessed against the same eligibility criteria, and 88 studies were excluded for the following reasons: (a) participants involved sensory disabilities or dementia, (b) intervention did not require physical environmental changes, (c) outcomes were not relevant to the predetermined behaviors in educational settings (e.g. employment and community participation), or (d) the research's context is not on the interior environment (e.g. community). Finally, 32 studies were included in the qualitative synthesis. All selected studies were reported in a peer-reviewed journal or dissertation (Ahrentzen & Steele, 2009; Beaver, 2011; Castell, 2012; Cermak et al., 2015; Courbois et al., 2013; Deochand et al., 2015; K. Gaines et al., 2016; K. S. Gaines et al., 2014; Hill et al., 2012; Hume & Odom, 2007; Khare & Mullick, 2009; Kinnealey et al., 2012; Lotan & Gold, 2009; Lowe et al., 2014; Marchi, 2013; McAllister & Mcguire, 2012; Mostafa, 2008, 2010, 2014; Nagib & Williams, 2017; Pfeiffer et al., 2017; Pierce et al., 2013; Salmi, 2007; Sánchez et al., 2011; Schilling & Schwartz, 2004; Scott, 2009; Slevin & Mcclelland, 1999; Steele & Ahrentzen, 2015; Vogel, 2008; Woodcock et al., 2007; Yuill et al., 2007; Zazzi & Faragher, 2018). Figure 2 depicts the flow of the screening and selection process.

Figure 2

Screening and Selection Process of Systematic Review



EBP Studies on Associations Between Environmental Attributes and Adaptive Behaviors

Characteristics of Selected Studies. When it comes to evidence-based practice in special education, there were twelve studies involving four types of research designs. There was one systematic review which involves meta-analysis, two randomized controlled trials (RTC), seven non-randomized controlled trials, and two descriptive observations (Table 1). If a study used a mixed-method design, the study was classified considering the type of data used for the synthesis of this study.

Seven out of nine experimental studies used single -subject experimental design (SSED), including AB single baseline design and ABAB withdrawal design. Two descriptive observations used qualitative interviews.

Table 1

Characteristics of the Selected Studies: Evidence-Based Practice (EBP)

Author (year)	**Study Design/ level of evidence**	**Participants N (M:F) Diagnosis/Age**	**Comparison**	**Independent Variables**	**Dependent Variables**
Cermak et al. (2015)	RCT Experimental randomized cross-over design/ 2	22 Autism/6-12	22 TD/6-12	Multisensory (modification)	PB (comfort)
Courbious et al. (2013)	RCT Natural experiment/ 2	15 (6:9) Intellectual disability/Mean18.15	15 (6:9) TD/Mean18.55	Visual Cues (Non-unique landmark), Text (less text signage)	AB (wayfinding)
Hill et al. (2012)	Non-randomized controlled trial SSED/ 3	2 Intellectual disability and autism (1:1)/14 and 18	NA	Multisensory	PB (stereotyped behaviors, attention)

Table 1 (Continued)

Characteristics of the Selected Studies: Evidence-Based Practice (EBP)

Author (year)	Study Design/ level of evidence	Participants N (M:F) Diagnosis/Age	Comparison	Independent Variables	Dependent Variables
Hume & Odom (2007)	Non-randomized controlled trial - SSED ABAB withdrawal design/ 3	3 Autism/ 6, 7, and 20	NA	Spatial Sequence and Routine, Visual Cues, Non-text	AB (independence measured by on/off task, task completion, teacher prompting, number of play material used).
Kinnealey et al. (2012)	Non-randomized controlled trial - SSED AB single baseline design/ 3	1 Classroom with 3 Autism and 1 Dyspraxia/13-20	NA	Low Arousal (Visual, Auditory)	PB (attention)
Lotan & Gold (2009)	Systematic review and/or meta-analysis/ 1	2 – 54 Intellectual and developmental disabilities and autism/5 - 65	NA	Multisensory	AB, PB
Pfeiffer et al. (2017)	Descriptive observational - Qual interview/ 6	34 Caregivers of children with autism	NA	Multisensory	AB (daily activity)
Pierce et al. (2013)	Non-randomized controlled trial - SSED ABAB withdrawal design/ 3	4 Autism/9 - 11	NA	Visual Activity Schedule	AB (daily activity, classroom transition)
Schilling & Schwartx (2004)	Non-randomized controlled trial - SSED ABAB withdrawal design/ 3	4 Autism/3-4	NA	Multisensory (Theraphy ball as seating)	PB (attention, in-seat behavior)

Table 1 (Continued)

Characteristics of the Selected Studies: Evidence-Based Practice (EBP)

Author (year)	Study Design/ level of evidence	Participants N (M:F) Diagnosis/Age	Comparison	Independent Variables	Dependent Variables
Slevin & Mcclelland (1999)	Non-randomized controlled trial - SSED AB single baseline design/ 3	1 Person with learning disabilities and challenging behavior	NA	Multisensory	PB (relaxation)
Yuill et al. (2007)	Non-randomized controlled trial - SSED AB single baseline design/ 3	8 Autism/5 - 7 (Mean 6)	NA	Social Area (physical challenge, support for imaginative play, structured move, observation point)	AB (Social interaction, play)
Zazzi & Faragher (2018)	Descriptive observation - Qual photo elicitation, draw and talk, semi-structured Interview/ 6	3 Autism/ 7 – 9	NA	Visual Clutter: Color, Congestion (crowdness), Affordances (layout), Size	PB (negative emotional response)

Note. AB: Adaptive Behaviors, and PB: Problem Behaviors

Study Quality. The selected studies were assessed by appraisal tools according to study designs. The nine quantitative studies were evaluated using "Quality Assessment Tool for Quantitative Studies," which assesses the following criteria: selection bias, study design, confounders, blinding, data collection, withdrawals and dropout (EPHPP; https://merst.ca/tools/). As a result of the assessment, seven studies were evaluated as strong and the remaining two studies as moderate (Table 2).

Table 2

Quality Assessment of Quantitative Studies: Evidence-Based Practice (EBP)

Criteria	Cermak et al. (2015)	Courbois et al. (2013)	Hill et al. (2012)	Hume & Odom (2007)	Kinnealey et al. (2012)	Pierce et al. (2013)	Schilling & Schwartx (2004)	Slevin & Mcclelland (1999)	Yuill et al. (2007)
Selection Bias - Are the individuals selected to participate in the study likely to be representative of the target population? - What percentage of selected individuals agreed to participate?	2	2	2	2	2	2	2	2	2
Study Design - Indicate the study design - Was the study described as randomized? - If yes, was the method of randomization described? - If yes, was the method appropriate?	1	1	1	1	1	1	1	1	1
Confounders - Were there important differences between groups prior to the intervention? - If yes, indicate the percentage of relevant confounders that were controlled.	1	3	NA	NA	NA	NA	NA	1	NA
Blinding - Was (were) the outcome assessor(s) aware of the intervention or exposure status of participants? - Were the study participants aware of the research question?	2	2	1	1	1	2	2	2	3
Data Collection Methods - Were data collection tools shown to be valid? - Were data collection tools shown to be reliable?	1	2	1	1	1	1	1	1	1
Withdrawals and Dropouts - Were withdrawals and dropouts reported in terms of numbers and/or reasons per group? - Indicate the percentage of participants completing the study. (If the percentage differs by groups, record the lowest).	1	NA	1	1	1	1	1	1	1

Table 2 (Continued)

Quality Assessment of Quantitative Studies: Evidence-Based Practice (EBP)

Criteria	Cermak et al. (2015)	Courbois et al. (2013)	Hill et al. (2012)	Hume & Odom (2007)	Kinnealey et al. (2012)	Pierce et al. (2013)	Schilling & Schwartx (2004)	Slevin & Mcclelland (1999)	Yüill et al. (2007)
Invention Integrity - What percentage of participants received the allocated intervention or exposure of interest? - Was the consistency of the intervention measured? - Is it likely that subjects received an unintended intervention (contamination or co-intervention) that may influence the results?	-	-	-	-	-	-	-	-	-
Analyses - Indicate the unit of allocation - Indicate the unit of analysis - Are the statistical methods appropriate for the study design? - Is the analysis performed by intervention allocation status (i.e. intention to treat) rather than the actual intervention received?	-	-	-	-	-	-	-	-	-
Total	1	2	1	1	1	1	1	1	2

Note. 1 – Strong, 2 – Moderate, 3 – Weak. Used the Quality Assessment Tool for Quantitative Studies (EPHPP; https://merst.ca/tools/).

Two qualitative studies were evaluated by the Critical Appraisal Skills Program (CASP) qualitative studies checklist, which includes ten questions in three sections: are the result of study valid? what are results? and will the results help locally? (CASP; https://casp-uk.net/casp-tools-checklists/) The selected two studies were evaluated as strong (Table 3).

Table 3

Quality Assessment of Qualitative Studies: Evidence-Based Practice (EBP)

Criteria	Pfeiffer et al. (2017)	Zazzi et al. (2018)
Are the results valid?		
- Was there a clear statement of the aims of the research?	1	1
- Is a qualitative methodology appropriate?	1	1
- Was the research design appropriate to address the aims of the research?	1	1
- Was the recruitment strategy appropriate to the aims of the research?	1	2
- Was the data collected in a way that addressed the research issue?	1	1
- Has the relationship between researcher and participants been adequately considered?	1	1
What are the results?		
- Have ethical issue been taken into consideration?	1	2
- Was the data analysis sufficiently rigorous?	1	1
- Is there a clear statement of findings?	1	1
Will the results help locally?		
- How valuable this research?	1	1
Total	1	1

Note. 1 – Yes, 2 – Cannot Tell, 3 – No. In total, 1 – Strong, 2 – Moderate, 3 – Weak. Used CASP qualitative studies checklist (CASP; https://casp-uk.net/casp-tools-checklists/)

One systematic review and meta-analysis study was evaluated by the CASP systematic review checklist. The CASP checklist asks ten questions in three sections: are the result of study valid? what are results? and will the results help locally? (CASP; https://casp-uk.net/casp-tools-checklists/) As a result, the selected study was assessed as strong (Table 4).

Table 4

Quality Assessment of Systematic Review: Evidence-Based Practice (EBP)

Criteria	Lotan & Gold (1009)
Are the results valid?	
Did the review address a clearly focused question?	1
Did the author look for the right type of papers?	1
Do you think all the important, relevant studies were included?	1
Did the review's authors do enough to assess quality of the included studies?	1
If the results of the review have been combined, was it reasonable to do so?	1
What are the results?	
What are the overall results of the review?	Qual
How precise are the results? (quan)	NA
Will the results help locally?	
Can the results be applied to the local population?	1
Were all important outcomes considered?	1
Are the benefits worth the harms and costs?	1
Total	1

Note. 1 – Yes, 2 – Cannot Tell, 3 – No. In total, 1 – Strong, 2 – Moderate, 3 – Weak. Qual – Qualitative Synthesis. Used CASP systematic review checklist (CASP; https://casp-uk.net/casp-tools-checklists/).

Findings and Limitations in EBP. Several EBP studies revealed that environmental changes contributed to adaptive and problem behaviors (Table 5). Spatial sequencing was effective in improving students' adaptive behaviors. (Hume & Odom, 2007; Zazzi & Faragher, 2018). Visually and physically structured sequences provided students opportunities to perform a series of tasks independently. Spatial sequence by logical orders, such as the orders of activities, routine, helped students to complete daily scheduled activities. Environmental cues also

improved students' independent performance of daily activities (Courbois et al., 2013; Pierce et al., 2013; Hume & Odom, 2007). Visual support was crucial in reminding students of which activities to be performed. Visual instruction enabled students to independently track activities. Specifically, visual cues with non-text components were effective to be recognized and understood by students with IDD (Courbois et al., 2013; Hume & Odom, 2007). Areas that assist gross-motor areas were associated with students' social skills (Yuill et al., 2007). Adequate design of gross-motor area promoted diverse social interaction. For instance, parallel and group play behaviors were observed more frequently in the play area with an appropriate level of a physical challenge than solitary play behaviors (Yuill et al., 2007). Low arousal environments were relevant to problem behaviors. Visually and auditorily controlled environments were effective in promoting attention (Kinnealey et al., 2012). The effectiveness of a multisensory environment on comfort and relaxation has been tested through a range of research methods, including meta-analysis, randomized controlled trials (RCT), single-subject experimental design (SSED), and qualitative interview (Cermak et al., 2015; Hill et al., 2012; Lotan & Gold, 2009; Slevin & Mcclelland, 1999).

Experimental studies identified the relationship between the environmental changes and students' behavioral outcomes and showed the strength of the association; however, most EBP studies employed a single-subject experimental design (SSED). Some identified strategies have not been supported by a sufficient number of studies. Since studies were limited to particular study designs with limited sample size, future study is required to validate the findings. Design features identified from qualitative studies also need to be further validated by repeated findings or inferential statistical testing, due to the relatively weak evidence level of such study design.

Table 5

Environmental Intervention for Adaptive and Problem Behaviors of People with IDD: Evidence Based Practice (EBP)

		Cermak et al. (2015)	Courbois et al. (2013)	Hill et al. (2012)	Hume & Odom (2007)	Kinnealey et al. (2012)	Lotan & Gold (2009)	Pfeiffer et al. (2017)	Pierce et al. (2013)	Schilling & Schwartx (2004)	Slevin & Mcclelland (1999)	Yuill et al. (2007)	Zazzi et al. (2018)
Coherence	**Routine**: Spatial sequencing by logical order (e.g. sequence of activities, routines, sensory characteristics, etc.)				A								A
Affordance	**Environmental Cue**: Presence of environmental cues (e.g. signage, visual instruction, landmarks, etc.)		A		A				A				
	Non-text: Non-text components used in cues (e.g. concrete figures, numbers, symbols, pictures, colors, etc.)		A		A								
Control	**Gross-motor Area: A**reas for gross motor (e.g. large open space with high ceilings, slide, swing, climbing, etc.)											A	
	Personal Space: Extended personal space (e.g. wide hallways, workstations, etc.)												A
Stimulation	**Low Arousal (Visual):** Absence of visual clutter (e.g. excessive colors, patterns, and flickering lighting)					P							A
	Low Arousal (Auditory): Noise control					P							
Restoration	**Multisensory**: Multiple options for sensory condition (e.g. high vs. low stimulus zones; containment vs. openness; with vs. without background sound; etc.)	P		P			A	A		P	P		

Note. A – design strategies associated with adaptive behaviors (conceptual skills/practical/social skills), P – design strategies associated with problem behaviors (attentional/ internalizing/ externalizing).

EBD Studies on Associations Between Environmental Attributes and Problem Behaviors

Characteristics of Selected Studies. When it comes to evidence-based design (EBD) studies in the environmental design field, the 20 selected studies employed a diverse range of research designs. There was one randomized controlled trial (RTC), one analytical observation, five reviews of descriptive studies, eleven descriptive observations, and two experts' reflective experiences (Table 6). In the same manner with categorizing the EBP studies, the mixed-method studies in EBD were also classified considering the type of data used for the synthesis of this study.

One experimental study and one analytical observational study identified the relationship showed the strength of the association between environmental attributes and students' behaviors (Khare & Mullick, 2009; Mostafa, 2008). The majority of EBD studies were categorized as descriptive observations. Eleven descriptive observations included research methods such as surveys, qualitative interviews, or case studies.

Table 6

Characteristics of the Selected Studies: Evidence-Based Design (EBD)

Author (year)	Study Design / level of evidence	Participants N (M:F) Diagnosis/Age OR Cases	Comparison	Independent Variables	Dependent Variables
Ahrentzen & Steel (2009)	Descriptive observational - Qual case study/ 6	9 Residential accommodations considered as best practices	NA	Multisensory, Escape Room, Social Area, Natural Light, Low Arousal (Tactile, Olfactory, Visual, Auditory), Spatial Sequencing and Routine, Proximity, Permanency, Transition, Visual Access, Building Shape, Visual Cue, Non-text, Contrast	Overall enhancement
Beaver (2011)	Expert's reflective experience/ 7	1 Residential-educational center	NA	Multisensory, Escape Room, Social Area, Personal Space, Low Arousal (Tactile, Visual, Auditory), Assistive Tech (Control)	Overall enhancement
Castell (2012)	Review of descriptive studies/ 5	NA (Literature regarding intellectual disability)	NA	Low Arousal (Visual, Auditory), Transition, Visual Cues, Repetition, Non-text, Contrast, Arrows, Highlight	AB (spatial cognition, wayfinding)
Deochand et al. (2015)	Descriptive Survey/ 6	101 Professionals	NA	Aesthetics and comfort: Multisensory, Escape Room, Social Area, Natural Light, Low Arousal (Visual and Auditory), Visual Access, Assistive Tech (Control)	Reported importance rate
Gaines et al. (2016)	Review of descriptive studies/ 5	NA (Literature regarding Autism)	NA	Multisensory, Natural Light, Low Arousal (Visual), Spatial Sequencing and Routine, Transition, Visual Cues, Non-text	Overall enhancement

Table 6 (Continued)

Characteristics of the Selected Studies: Evidence-Based Design (EBD)

Author (year)	Study Design / level of evidence	Participants N (M:F) Diagnosis/Age	Comparison	Independent Variables	Dependent Variables
Gaines et al. (2014)	Descriptive Survey/ 6	546 Teachers of students with autism	NA	Low Arousal (Visual; Minimizing Visual Clutter)	PB (hyper-sensitivity)
Khare & Mullick (2009)	Analytical observation – Correlation/ 4	17 Classes in 12 schools, 20 experts /5 – 18	NA	Escape Room, Social Area, Personal Space, Low Arousal (Tactile, Olfactory, Visual, Auditory), Spatial Sequencing and Routine, Proximity, Permanency, Transition, Building Shape, Visual Cue, Non-text, Highlight	Overall enhancement
Lowe et al. (2014)	Expert's reflective experience/ 7	1 Residential-educational accommodation	NA	Multisensory, Escape Room, Low Arousal (Tactile, Olfactory, Visual, Auditory), Permanency, Visual Access, Visual Cues	Overall enhancement
Marchi (2013)	Review of descriptive studies/ 5	NA (Literature regarding Autism)	NA	Escape Room, Social Area, Natural Light, Naturalness, Personal Space, Low Arousal (Visual, Auditory), Permanency, Transition, Visual Access	Overall enhancement
Mcallister & Maguire (2012)	Descriptive observational - Rank survey + focus group/ 6	9 Class for ASD/5 - 8, 1 Class for ASD/11 - 16 (one teacher, 2 assistants, 8 students)	NA	Multisensory, Escape Room, Naturalness, Personal Space, Proximity, Permanency, Visual Access, Visual Cue	Reported importance rate

Table 6 (Continued)

Characteristics of the Selected Studies: Evidence-Based Design (EBD)

Author (year)	Study Design / level of evidence	Participants N (M:F) Diagnosis/Age	Comparison	Independent Variables	Dependent Variables
Mostafa (2010)	Descriptive observation - Case study/ 6	1 residential accommodation	NA	Multisensory, Natural Light, Naturalness, Low Arousal (Tactile, Olfactory, Auditory), Spacial Sequencing and Routine, Proximity, Permanency, Visual Access, Visual Cue, Non-text	Overall enhancement
Mostafa (2008)	RCT - Rank survey + SSED AB design/ 2	Survey: 83 Caregivers and teachers Intervention study: 1 Autism class with 6 students/ 6 - 10 (Mean 8.33, SD 1.63)	1 ASD Class with 6 students/ 6 - 10 (Mean 7.50, SD 1.64)	Spatial Sequence and Routine, Low Arousal (Auditory)	PB (attention span, response time, self-stimulatory behaviors)
Mostafa (2014)	Descriptive observation - Case study/ 6	1 Learing center for autism	NA	Multisensory, Escape Room, Low Arousal (Auditory), Spatial Sequencing and Routine, Permanency, Transition	Reported importance rate
Nagib & Williams (2017)	Descriptive observational - Qual interview/ 6	4 Architects, 11 occupational therapist, and 168 family with autism	NA	Escape Room, Social Area, Natural Light, Low Arousal (Visual, Auditory), Spatial Sequencing and Routine, Assistive Tech (Control)	Overall enhancement
Salmi (2007)	Descriptive observation - Qual interview/ 6	10 (6:4) Intellectual disability/Mean 39	NA	Spatial organization, signage, landmark, map/directories, environmental sensory cues	AB (spatial cognition, wayfinding)

Table 6 (Continued)

Characteristics of the Selected Studies: Evidence-Based Design (EBD)

Author (year)	Study Design / level of evidence	Participants N (M:F) Diagnosis/Age	Comparison	Independent Variables	Dependent Variables
Sanchez et al. (2011)	Review of descriptive studies/ 5	NA (Literature regarding autism)		Multisensory, Social Area, Personal Space, Low Arousal (Tactile, Olfactory, Visual, Auditory), Spatial Sequencing and Routine, Permanency, Visual Access, Visual Cue, Non-text,	Overall enhancement
Scott (2009)	Descriptive observation - Case study/ 6	1 Center for autism	NA	Multisensory, Escape Room, Spatial Sequencing and Routine, Permanency, Building Shape,	Overall enhancement
Steele & Ahrentzen (2015),	Review of descriptive studies/ 5	NA (Literature regarding autism)	NA	Multisensory, Escape Room, Social Area, Natural Light, Personal Space, Low Arousal (Tactile, Olfactory, Visual, Auditory), Spatial Sequencing and Routine, Proximity, Permanency, Transition, Visual Access, Building Shape, Visual Cue, Non-text, Contrast	Overall enhancement
Vogel (2008)	Descriptive observation - Qual interview/ 6	parents, teachers, and therapists, and adults with autism	NA	Multisensory, Escape Room, Social Area, Natural Light, Personal Space, Low Arousal (Visual, Auditory), Transition, Visual Access, Visual Cue	Overall enhancement

Table 6 (Continued)

Characteristics of the Selected Studies: Evidence-Based Design (EBD)

Author (year)	Study Design / level of evidence	Participants N (M:F) Diagnosis/Age	Comparison	Independent Variables	Dependent Variables
Woodcock et al. (2007)	Survey, Observation, qualitative interview/ 6	Survey: 500 Autism, Interview: 25 Asperger's syndromes, autism, Observation: 8 Autism/not known	NA	Multisensory	PB (hyper or hypo sensitivity)

Note. AB – Adaptive Behaviors, PB – Problem Behaviors

Study Quality. The identical appraisal tools, which have been used for evaluating EBP studies, were applied to when analyzing EBD study quality. Specifically, six quantitative studies were evaluated by "Quality Assessment Tool for Quantitative Studies," which assesses criteria: selection bias, study design, confounders, blinding, data collection, withdrawals and dropout (EPHPP; https://merst.ca/tools/). As a result of the assessment, four studies were evaluated as moderate, and two studies as weak (Table 7).

Table 7

Quality Assessment of Quantitative Studies: Evidence-Based Design (EBD)

Criteria	Deochand et al. (2015)	Gaines et al. (2014)	Khare & Mullick (2009)	Mcallister & Maguire (2012)	Mostafa (2008)	Woodcock et al. (2007)
Selection Bias - Are the individuals selected to participate in the study likely to be representative of the target population? - What percentage of selected individuals agreed to participate?	2	1	2	2	2	2
Study Design - Indicate the study design - Was the study described as randomized? - If yes, was the method of randomization described? - If yes, was the method appropriate?	3	3	3	3	1	3
Confounders - Were there important differences between groups prior to the intervention? - If yes, indicate the percentage of relevant confounders that were controlled.	NA	NA	NA	NA	3	NA
Blinding - Was (were) the outcome assessor(s) aware of the intervention or exposure status of participants? - Were the study participants aware of the research question?	NA	NA	NA	NA	2	NA
Data Collection Methods - Were data collection tools shown to be valid? - Were data collection tools shown to be reliable?	2	3	2	2	1	3
Withdrawals and Dropouts - Were withdrawals and dropouts reported in terms of numbers and/or reasons per group? - Indicate the percentage of participants completing the study. (If the percentage differs by groups, record the lowest).	NA	NA	NA	NA	1	NA
Invention Integrity - What percentage of participants received the allocated intervention or exposure of interest? - Was the consistency of the intervention measured? - Is it likely that subjects received an unintended intervention (contamination or co-intervention) that may influence the results?	-	-	-	-	-	-

Table 7 (Continued)

Quality Assessment of Quantitative Studies: Evidence-Based Design (EBD)

Criteria	Deochand et al. (2015)	Gaines et al. (2014)	Khare & Mullick (2009)	Mcallister & Maguire	Mostafa (2008)	Woodcock et al. (2007)
Analyses - Indicate the unit of allocation - Indicate the unit of analysis - Are the statistical methods appropriate for the study design? - Is the analysis performed by intervention allocation status (i.e. intention to treat) rather than the actual intervention received?	-	-	-	-	-	-
Total	2	3	2	2	2	3

Note. 1 – Strong, 2 – Moderate, 3 – Weak. Used the Quality Assessment Tool for Quantitative Studies (EPHPP; https://merst.ca/tools/).

Nine qualitative studies were evaluated by the CASP qualitative studies checklist, which includes ten questions in three sections: are the result of study valid? what are results? and will the results help locally? (CASP; https://casp-uk.net/casp-tools-checklists/) There were three strong, five moderate, and one weak qualitative study (Table 8).

Table 8

Quality Assessment of Qualitative Studies: Evidence-Based Design (EBD)

Criteria	Ahrentzen & Steele (2009)	Beaver (2011)	Lowe et al. (2014)	Mostafa (2010)	Mostafa (2014)	Nagib & Williams (2017)	Salmi (2007)	Scott (2009)	Vogel (2008)
Are the results valid?									
- Was there a clear statement of the aims of the research?	1	1	1	1	1	1	1	1	3
- Is a qualitative methodology appropriate?	1	2	1	1	1	1	1	1	2
- Was the research design appropriate to address the aims of the research?	1	2	1	1	1	1	1	1	2
- Was the recruitment strategy appropriate to the aims of the research?	1	NA	2	2	2	1	1	2	2
- Was the data collected in a way that addressed the research issue?	1	NA	2	2	2	1	1	1	2
- Has the relationship between researcher and participants been adequately considered?	2	NA	2	2	2	2	1	2	2
What are the results?									
- Have ethical issue been taken into consideration?	2	3	3	3	3	1	1	3	3
- Was the data analysis sufficiently rigorous?	2	NA	2	2	2	1	1	2	3
- Is there a clear statement of findings?	1	2	1	1	1	1	1	1	2
Will the results help locally?									
- How valuable this research?	1	1	1	1	1	1	1	1	1
Total	1	2	2	2	2	1	1	2	3

Note. 1 – Yes, 2 – Cannot Tell, 3 – No. In total, 1 – Strong, 2 – Moderate, 3 – Weak. Used CASP qualitative studies checklist (CASP; https://casp-uk.net/casp-tools-checklists/)

Five literature review studies were evaluated by the CASP systematic review checklist, using ten questions in three sections: are the result of study valid? what are results? and will the results help locally? (CASP; https://casp-uk.net/casp-tools-checklists/) As a result, one study was assessed as strong, three as moderate, and one as weak (Table 9).

Table 9

Quality Assessment of Systematic Review: Evidence-Based Design (EBD)

Criteria	Castell (2012)	Gaines et al. (2016)	Marchi (2013)	Sanchez et al. (2011)	Steele & Ahrentzen (2015)
Are the results valid?					
- Did the review address a clearly focused question?	1	1	1	1	1
- Did the author look for the right type of papers?	1	1	2	1	1
- Do you think all the important, relevant studies were included?	3	2	2	2	1
- Did the review's authors do enough to assess quality of the included studies?	3	3	3	3	2
- If the results of the review have been combined, was it reasonable to do so?	1	1	1	1	1
What are the results?					
- What are the overall results of the review?	Qual	Qual	Qual	Qual	Qual
- How precise are the results? (quan)	NA	NA	NA	NA	NA
Will the results help locally?					
- Can the results be applied to the local population?	1	1	1	1	1
- Were all important outcomes considered?	1	1	1	1	1
- Are the benefits worth the harms and costs?	1	1	1	1	1
Total	3	2	2	2	1

Note. 1 – Yes, 2 – Cannot Tell, 3 – No. In total, 1 – Strong, 2 – Moderate, 3 – Weak. Qual – Qualitative Synthesis. Used CASP systematic review checklist (CASP; https://casp-uk.net/casp-tools-checklists/).

Findings and Limitations in EBD. EBD studies have contributed to identifying a variety of design strategies (Table 10). However, the majority of EBD studies were categorized as descriptive observations. Research methods, such as surveys, qualitative interviews, or case studies, had a limitation that the target outcomes had not been specified, rather, the studies considered overall functional enhancement. Specifically, the survey method usually asked

caregivers' reported importance rate. The selected case studies were often based on experts' reflective experience. These types of data can get easily biased and have limitations in internal validity. The identified design features with relatively weak evidence will get validity when future studies show repeated findings (higher reliability) or test them by using inferential statistical analysis toward specific functional outcomes.

Table 10

Environmental Intervention for Adaptive and Problem Behaviors of People with IDD: Evidence-Based Design (EBD)

		Ahrentzen & Steele (2009)	Beaver (2011)	Castell (2012)	Deochand et al. (2015)	Gaines et al. (2014)	Gaines et al. (2016)	Khare & Mullick (2009)	Lowe et al. (2014)	Marchi (2013)	Mcallister & Maguire (2012)	Mostafa (2008)	Mostafa (2010)	Mostafa (2014)	Nagib & Williams (2017)	Salmi (2007)	Sanchez et al. (2011)	Scott (2009)	Steele & Ahrentzen (2015)	Vogel (2008)	Woodcock et al. (2007)
Coherence	**Routine**: Spatial sequencing by logical order (e.g. sequence of activities, routines, sensory characteristics, etc.)	○					○	○					○	○	○		○	○	○		
	Efficient Circulation: Direct and short routes (e.g. from classroom/study area to restrooms, external play areas, etc.)	○						○			○		○					○	○		

Table 10 (Continued)

Environmental Intervention for Adaptive and Problem Behaviors of People with IDD: Evidence-Based Design (EBD)

		Ahrentzen & Steele (2009)	Beaver (2011)	Castell (2012)	Deochand et al. (2015)	Gaines et al. (2014)	Gaines et al. (2016)	Khare & Mullick (2009)	Lowe et al. (2014)	Marchi (2013)	Mcallister & Maguire (2012)	Mostafa (2008)	Mostafa (2010)	Mostafa (2014)	Nagib & Williams (2017)	Salmi (2007)	Sanchez et al. (2011)	Scott (2009)	Steele & Ahrentzen (2015)	Vogel (2008)	Woodcock et al. (2007)
Coherence	**Compartmentalization**: Single function and clear boundary	○						○	○	○	○	P	○	○			○	○	○		
	Visual Access: Clear visual access and openness (e.g. use of half-walls, preview windows, open floorplan, etc.).	○							○	○	○		○			A			○	○	
	Repetition: Cohesive navigational aids (e.g. consistent color coding, graphics, etc.).			○												A					
	Building Shape: Simple building shape (e.g. the minimized floors, corners, intersections, and length of hallways).	○						○								A		○	○		
Affordance	**Environmental Cue**: Presence of environmental cues (e.g. signage, visual instruction, landmarks, etc.)	○		○		A	○	○	○		○		○			A	○		○	○	

Table 10 (Continued)

Environmental Intervention for Adaptive and Problem Behaviors of People with IDD: Evidence-Based Design (EBD)

		Ahrentzen & Steele (2009)	Beaver (2011)	Castell (2012)	Deochand et al. (2015)	Gaines et al. (2014)	Gaines et al. (2016)	Khare & Mullick (2009)	Lowe et al. (2014)	Marchi (2013)	Mcallister & Maguire	Mostafa (2008)	Mostafa (2010)	Mostafa (2014)	Nagib & Williams (2017)	Salmi (2007)	Sanchez et al. (2011)	Scott (2009)	Steele & Ahrentzen (2015)	Vogel (2008)	Woodcock et al. (2007)
Affordance	**Non-text**: Non-text components used in cues (e.g. concrete figures, numbers, symbols, pictures, colors, etc.)	○		○			○	○					○			A	○		○		
	Text: Text at lower secondary education level with recognizable font (sanserif font), size and spacing.					A										A					
	Contrast: Apparent color contrast	○		○												A			○		
	Symbols: Recognizable and understandable symbols (e.g. arrows)			○												A					
	Highlight: highlighted information (e.g. bold text, illumination, perpendicular installation, etc.)			○				○								A					

Table 10 (Continued)

Environmental Intervention for Adaptive and Problem Behaviors of People with IDD: Evidence-Based Design (EBD)

		Ahrentzen & Steele (2009)	Beaver (2011)	Castell (2012)	Deochand et al. (2015)	Gaines et al. (2014)	Gaines et al. (2016)	Khare & Mullick (2009)	Lowe et al. (2014)	Marchi (2013)	Mcallister & Maguire	Mostafa (2008)	Mostafa (2010)	Mostafa (2014)	Nagib & Williams (2017)	Salmi (2007)	Sanchez et al. (2011)	Scott (2009)	Steele & Ahrentzen (2015)	Vogel (2008)	Woodcock et al. (2007)
Control	**Social Area:** Areas for socialization (e.g. general purpose/dining area, niche/alcove within corridor, etc.)	○	○		○		○	○		○					○		○		○	○	
	Gross-motor Area: Areas for gross motor (e.g. large open space with high ceilings, slide, swing, climbing, etc.)				○										○						
	Quiet Area: Areas for coping with stress in social interaction	○	○		○		○	○	○	○	○			○	○	A		○	○	○	
	Personal Space: Extended personal space (e.g. wide hallways, workstations, etc.)		○					○		○	○						○	○	○	○	○

Table 10 (Continued)

Environmental Intervention for Adaptive and Problem Behaviors of People with IDD: Evidence-Based Design (EBD)

		Ahrentzen & Steele (2009)	Beaver (2011)	Castell (2012)	Deochand et al. (2015)	Gaines et al. (2014)	Gaines et al. (2016)	Khare & Mullick (2009)	Lowe et al. (2014)	Marchi (2013)	Mcallister & Maguire	Mostafa (2008)	Mostafa (2010)	Mostafa (2014)	Nagib & Williams (2017)	Salmi (2007)	Sanchez et al. (2011)	Scott (2009)	Steele & Ahrentzen (2015)	Vogel (2008)	Woodcock et al. (2007)
Stimulation	**Low Arousal (Tactile):** Consistent indoor temperature	○	○				○	○	○				○				○	○	○		○
	Low Arousal (Olfactory): Consistent indoor air quality	○	○				○	○	○				○				○	○	○		○
	Low Arousal (Visual): Absence of visual clutter (e.g. excessive colors, patterns, and flickering lighting)	○	○	○	P		○	○	○	○					○		○		○	○	○
	Low Arousal (Auditory): Noise control	○	○	○			○	○	○	○		P	○	○	○		○		○	○	○
	Assistive Tech: Assistive technology used to control environment (e.g. electrical appliances controller, blind controller, virtual assistant, etc.)	○																○	○		

Table 10 (Continued)

Environmental Intervention for Adaptive and Problem Behaviors of People with IDD: Evidence-Based Design (EBD)

		Ahrentzen & Steele (2009)	Beaver (2011)	Castell (2012)	Deochand et al. (2015)	Gaines et al. (2014)	Gaines et al. (2016)	Khare & Mullick (2009)	Lowe et al. (2014)	Marchi (2013)	Mcallister & Maguire	Mostafa (2008)	Mostafa (2010)	Mostafa (2014)	Nagib & Williams (2017)	Salmi (2007)	Sanchez et al. (2011)	Scott (2009)	Steele & Ahrentzen (2015)	Vogel (2008)	Woodcock et al. (2007)
Restoration	**Multisensory**: Multiple options for sensory condition (e.g. high vs. low stimulus zones; containment vs. openness; with vs. without background sound; etc.)	○	○		○		○		○		○		○	○			○	○	○	○	P
	Transition: Transition zones to recalibrate students' senses	○		○			○	○		○				○		A	○		○	○	
	Natural Light: Natural light from outside	○			○	○	○			○			○		○			○	○	○	
	Natural Scene: Natural scene from outside	○				○	○												○		
	Naturalness: Natural features found inside of the building (e.g. materials, artwork, plants, etc.)						○			○	○		○								

Note. ○ – mentioned in the literature, but associations have not been addressed
A – design strategies associated with adaptive behaviors (conceptual skills/practical/social skills)
P – design strategies associated with problem behaviors (attentional/internalizing/externalizing)

Method

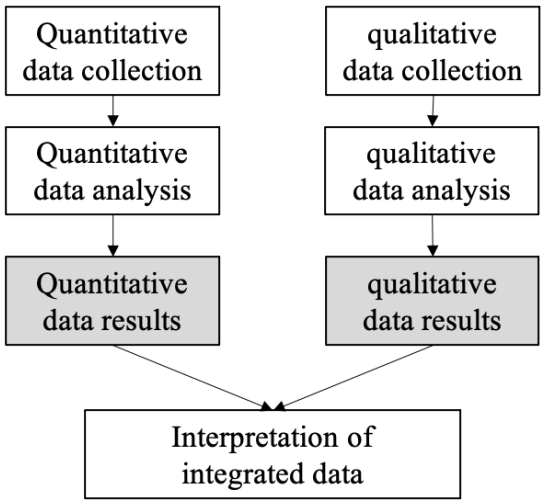
The purpose of the presented regression analysis was to examine the relationship between the physical environment and students' functional independence. This study measured the physical environment by the 26 items in the initial design guideline for people with intellectual and developmental disabilities (DG-IDD) identified by the systematic review from the previous section. The effectiveness of the initial DG-IDD items was accessed in explaining adaptive and problem behaviors that people with intellectual and developmental disabilities (IDD) could potentially exhibit in their learning environments. Caregivers, teachers, and service providers were recruited for a quantitative survey. Subsequent child interview was designed as a whole mixed-method research project, however, the presented report focused on quantitative analysis. This study used multiple regression to test the hypothesis that the presence of DG-IDD items in the learning environment will impact on students' adaptive and problem behaviors.

Study Design

The current study is a quantitative part of a larger mixed-method research, in which the quantitative survey and qualitative interview are concurrent. According to Creswell and Clark's (2003) classification, this research is identified as a concurrent triangulation strategy (Figure 3).

Figure 3

Concurrent Triangulation Design



Note. Image adapted from Creswell & Clark (2017)

This study uses mixed methods under two rationales. The primary rationale is 'complementary', using a different type of data to enhance, elaborate, and clarify the results from another (Greene et al., 1989). The quantitative survey measures the impacts of environmental features (IV) on observed behaviors (DV) through caregivers' observation. The followed qualitative interview seeks to further elaborate the environmental influence by collecting direct and in-depth information from people with IDD. Using a combination of both forms of data will provide the most complete elaboration, increasing the interpretability, meaningfulness, and validity of results.

The secondary rationale is for 'expansion', seeking to extend the range of inquiry by using different methods for different inquiry components (Greene et al., 1989). This study aims to accomplish two goals that require both quantitative and qualitative senses. The quantitative inquiry attempts to analyze how much the design elements influence cognitive functioning, while

the qualitative inquiry seeks to understand how the design elements support specific functional capabilities. Multiple inquiry component will increase comprehensive understanding.

Sample

This study recruited caregivers, educators, and service providers of people with IDD, who were (1) at the age of 14 – 18; (2) receiving special education; (3) categorized as Autism Spectrum Disorders (ASD) or intellectual disability, and (4) classified as mild intellectual disability (approximate IQ 50 – 69, mental age 9-12), or moderate intellectual disability (approximate IQ 36 – 49, mental age 6 – 9). Further participation eligibility criteria are described in Table 11. The presented study did not limit the environmental settings according to the types of buildings. This research considered any students placed either in a general education class, a special education class, a special education school, or the other settings listed in Table 11.

Table 11

Participation Eligibility Criteria

Respondents Demographic Information	
Nationality	South Korea United States
Relation	Classroom Teacher Counselor Special Educator Administrator Parent Grandparents Others
Gender	Female Male Non-binary/third gender
Work Period, if not parent or grandparents	Less than 1 year 1 year to less than 5 years 5 year to less than 10 years 10 year to less than 15 years 15 years and more

Table 11 (Continued)

Participation Eligibility Criteria

Students Demographic Information	
Nationality	South Korea United States
Age	14-18
Gender	Female Male Non-binary/third gender
Disability Types (IDEA definition)	(Select all that apply) Autism Spectrum Disorders (ASD) Intellectual disability
Disability Levels (WHO ICD)	Mild intellectual disability (approximate IQ range 50 – 69, mental age 9-12) Moderate intellectual disability (approximate IQ range 35 – 49, mental age 6 – 9)
Educational settings (SPED placement codes)	Separate special education school Separate special education class Inside regular class Separate day facility Home Homebound/hospital Residential facility Correctional facility Service provider location

The eligibility criteria were determined for the following reasons. In the environmental approach to decrease dependency level, the population with mild and moderate disabilities are specifically crucial for the successful transition to independent living. Those with severe or profound IDD are highly likely to require caregivers' assistant in conducting daily performances even though environmental support is provided. However, the population with mild, moderate intellectual disability has the potential to be independent without caregivers' assistant or with minimal supervision or setup if an adequate environment is provided. In the same manner, the population at the upper secondary education level is also important. As a student turns fourteen years old, transition planning is included as a part of the Individualized Education Plan (IEP).

Investigating the behaviors of this group is expected to improve the effectiveness of IEP, increasing the success rate of the population's transition to independent living through environmental intervention.

Instrumentation

Three measures were used for the quantitative analysis. The Environmental Evaluation (EE) was used to measure independent variable of environmental attributes. The Performance Measure (PM) and the Brief Problem Monitor (BPM) were used to measure two dependent variables of adaptive behavior and problem behaviors, respectively. A set of EE and PM, developed by Khare & Mulluck (2009), were modified for this study's purpose. The original EE and PM set was to assess the environmental impacts on people with autism spectrum disorders (ASD). Expanding the population to people with intellectual and developmental disabilities (IDD), the presented study reworded, eliminated, and added the survey questions to facilitate its expanded use. The BPM is a reliable, existing instrument that measures problem behaviors. The BPM was used with permission from the Achenbach System of Empirically Based Assessment (ASEBA) under license number 2215-01-04-21.

Modification of existing measure

The existing instrument, a set of EE and PM, was modified through the following process recommended by Maylor et al. (2005): (1) identifying additional items from the systematic literature review and defining response format, (2) determining the structure based on theoretical rationale, (3) receiving feedback from expert judges for appropriateness (content validity) and clarity (wording), (4) identifying potential problems through small group respondents, and (5) determining final structure to be used for this study. To test the divergent validity of the modified instrument, the EE and PM were combined with an existing measure, the Brief Problem Measure

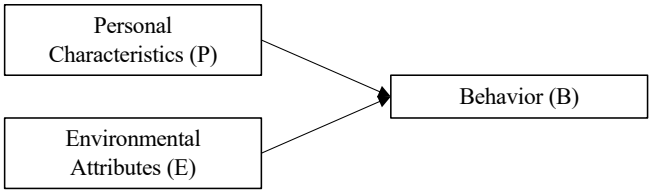
(BPM), which is hypnotized to correlate negatively with EE and PM. Cronbach alpha was used to test the modified measure's internal consistency.

Theoretical Rationale

This section is based on previously a published paper by Yi and Ellis (2021). Studies on the human-environment relationship are based on Kurt Lewin's (1936) ecological equation, B = f (P,E), where B is a behavior, P is a person, and E is an environment. Lewin's model illustrates the notion that behavior is a function of the relationship between the internal factors within the person and the external factors from one's environment as they are perceived. In other words, not only the personal factors but also environments can affect human behaviors either positively or negatively (Figure 4).

Figure 4

Person-Environment (P-E) Transactional Model



Note. Adapted from Kurt Lewin (1936)

Lawton and Nahemow (1973) specified the person-environment transaction in terms of a person's competence and environmental press. The person (P) was understood with regard to one's competence, such as the domains of health, sensorimotor, cognitive functioning, and ego strength (Lawton & Nahemow, 1973). The environment (E) was explained by the environmental press, which considers the demand character of the environment in which a person behaves. The outcome behaviors from the person-environment transaction (B) were classified as positive affect, or adaptive behavior, and negative affect, or maladaptive behavior. According to Lawton

and Nahemow's (1973) model, the adaptive behaviors occur at an "adaptation level," and its surrounding "zone of maximum comfort or performance potential," where the level of environmental demand is in balance with the person's ability. On the other hand, the maladaptive behaviors are caused by imbalance, when environmental demand exceeds a person's competence (challenging), or when a person's competence surpasses a certain level of the environmental press (boredom).

Kahana (1974) further conceptualized the adaptation level in Lawton and Nahemow's model with the term congruence, or fit. Person-Environment (P-E) fit is a state where a person's needs are congruent with what the environment offers. According to the P-E fit model, the fit brings favorable states, such as psychological well-being, preference, and capability, while a misfit requires modification of the environment, or if unsuccessful, leads to negative status, stress, dissatisfaction, or disability.

Pioneering attempts to establish a theoretical framework of studies on the relationship between physical environment and disability explicitly addressed the fit between person and environment (Edward Steinfeld & Danford, 1999). With the perspective of the P-E fit model, the barrier-free, accessible, enabling environments can be conceptualized as a needs-supply fit, in which a user's functional requirements are congruent with environmental supply. Meanwhile, the disabling environment can be explained as higher demand of the environment compared to an individual's capability.

The variables in the equation, P, E, and B, can be replaced with specific personal or situational characteristics, known as behavior settings (Barker, 1963). For this research's purpose of seeking an optimal environment that meets the needs of people with intellectual and developmental disabilities (IDD), the presented study extended the P-E fit model by substituting

the variable of P to students with IDD, E to learning environments, and B to functional independence. Based on the P-E fit model, this study relied on the assumption that functional independence (B) of students with IDD can be maximized (enabled) by providing an adequate learning environment (E) in balance with their cognitive functioning (P). This research's attempt is also based on the idea that the state of balance (fit) is definable and attainable (Khare & Mullick, 2009; Edward Steinfeld & Danford, 1999). Given the assumptions, the premise of the Person-Environment (P-E) fit model leads to the next question of measuring the extent to which a fit is attained.

Measuring Environmental Attributes. There are two approaches to measure environmental attributes. One is to describe environments in terms of physical characteristics, such as size, a quantity of objects, lighting level, etc. The other is to measure an environment in relation to users' needs (Lantrip, 1999). The second method considers users' needs and quantifies the presence of values that can support or interfere with the needs. In other words, the environmental qualities can be assessed in terms of characteristics that may contribute to the outcome, specifically in this study, how much they enable students' performance. This study employed the second approach in developing environmental measures.

To measure enabling attributes of an environment, it is crucial to define taxonomies to be considered to predict the mechanisms of human response to the environment. Evans and McCoy (1998) suggested five taxonomies of design attributes that could potentially affect users' adaptive functioning resources: coherence, affordance, control, stimulation, and restoration. These five dimensions are useful to measure the demand characteristics of the environment. The environments having the five attributes indicate that such environments make smaller behavioral

demands on people within them, in other words, could support the people with IDD in the environment.

Coherence refers to "clarity or comprehensibility of building elements and form" (Evans & McCoy, 1998, p.87). Similar concepts include legibility, continuity, while opposite concepts are complexity, changes. People with IDD are often attentive to details of space (Kawakubo et al., 2007), meanwhile, they have difficulty integrating environmental information as a whole context (Landry & Bryson, 2004; Townsend & Courchesne, 1994). People with IDD desire the comfort of continuity while showing reduced adaptability to changes (Steele & Ahrentzen, 2015). Coherence is an environmental feature that helps people with IDD reduce cognitive overload and organize the context of environments.

Affordance is defined as a quality that makes users predict the functions of an object or space (Evans & McCoy, 1998). Ambiguity is the opposite value, which occurs when vague, missing, or competing cues exist. It is crucial to prompt people with IDD through environmental cues as they exhibit challenges in attention span and memory (Sánchez et al., 2011). It is also critical to provide perceptible cues because they are often unable or slow to interpret written languages or abstract symbols (Yalon-Chamovitz, 2009). Affordance is an attribute that assists people with IDD to adequately use a space or object according to its function.

Control is a feature that lets users regulate their exposure to desired surroundings or alter the physical environment (Evans & McCoy, 1998). Physical constraints that reduce choice or behavioral options in social situations can cause stress (Zimring, 1981). Appropriate regulation of social interaction is especially important for people with IDD as they tend to resist having other people close to them (K. Gaines et al., 2016). Thus, alternative size and layout should be considered when designing social areas for people with IDD. Control is an environmental

characteristic that enables people with IDD to choose or regulate their social interaction according to their needs.

Stimulation is the amount of sensory information from the surrounding environment (Evans & McCoy, 1998). Examples of environmental stimuli include light, color, noise, smell, and so on. Both under and over stimulation negatively affect psychological well-being. People with IDD are associated with sensory integration dysfunction (SID), which shows an abnormal response to sensory stimuli in a form of hyper or hyposensitivity. People with IDD may be extremely sensitive to or underwhelmed by visual, auditory, tactile, olfactory, gustatory, vestibular, or proprioceptive stimuli in the environment. As a result, they can exhibit negative reactions, like stereotyped, repetitive, self-stimulatory, or other problem behaviors (Steele & Ahrentzen, 2015; Marchi, 2013). Stimulation is a potential environmental feature that could make people with IDD comfortable, pleasant within the exposed surroundings so prevent the occurrence of problem behaviors.

Restoration is a therapeutical feature of an environment that attenuates negative reactions by providing rest, recovery, or cotemplation (Evans & McCoy, 1998). People with IDD are vulnerable to stress and have limited coping strategies. Possibilities are high in people with IDD to show the neuropsychiatric symptoms including apathy, depression, anxiety, irritability, agitation, disinhibition, fear, anger, frustration, and sleep disorders (Terracciano, Stephan, Luchetti, Albanese, & Sutin, 2017; Forlenza et al., 2013; Kazui et al., 2011;). The environmental design should consider the situation when problem behaviors are externalized as self-injurious and aggressive behaviors. Restorative features in environments support people with IDD to cope with stress and address behavior problems when they occur.

Measuring Outcome Behaviors. Based on the Person-Environment (P-E) fit model, a fit between a person's needs and environmental characteristics brings adaptive behaviors, while misfit causes maladaptive behaviors. Given the assumption, this study considers adaptive and maladaptive behaviors as dependent variables. The field of special education has been involved in identifying constructs and developing instruments for measuring students' adaptive and maladaptive behaviors.

Adaptive behaviors refer to the skills that people need to function independently in their daily lives (Schalock et al., 2010). There have been several rating measures of adaptive behavior, such as the Adaptive Behavior Scale – School 2nd edition (ABS-S2), the Adaptive Behavior Assessment System – 2nd edition (ABAS 2), the Vineland Adaptive Behavior Scales – 2nd edition (Vineland 2), and the Scales of Independent Behavior – Revised (SIB-R). However, the American Association on Intellectual and Developmental Disabilities (AAIDD) has addressed the limitations of the existing measures and developed its own instrument, called the Diagnostic Adaptive Behavior Scale (DABS) (Harris & Greenspan, 2016). This study used the three constructs defined in the DABS by AAIDD: conceptual, practical, and social skills (Tassé et al., 2012; Schalock et al., 2010).

Conceptual Skills are the abilities that deal with abstract concepts and ideas, specifically, language and literacy, money, time, number, and self-direction (AAIDD, n.d.). These skills are underlying competence to acquire practical skills. With specific regards to the interactions between the human and physical environment, this study also considers an understanding of spatial context under conceptual skills.

Practical Skills refers to hands-on skills necessary to perform everyday lives, including activities of daily living, personal care, occupational skills, healthcare, travel/transportation,

schedules/routines, safety, and use of money (AAIDD, n.d.). Considering this study's scope of educational settings, this study involves necessary skills regarding school living.

Social Skills are defined as skills relevant to interaction with others, for example, interpersonal skills, social responsibility, self-esteem, and the ability to follow rules (AAIDD, n.d.). The present study also engages social interactions potentially presented in learning environments, including coping, leisure, and play.

In contrast, maladaptive behaviors are defined as human behaviors that interfere with the independence of daily activities. Maladaptive behaviors that people with IDD often display are self-injurious behavior (SIB), stereotypic behavior, and aggressive/destructive behavior (Rojahn, Zaja, Turygin, Moore, & Ingen, 2012). When it comes to measuring maladaptive behaviors, the development of the Child Behavior Checklist (CBCL) is a pioneering work that has divided behavior problems into internalizing and externalizing conditions. The CBCL has been widely used and backed by extensive research since its origin in the 1960s (Achenbach, 2009). Later, the Brief Problem Monitor (BPM) has been developed as an abbreviated version of CBCL, showing high correlations to CBCL in the total and subscale scores (Piper et al., 2014). This study uses the second-order factors of the BPM as constructs of problem behaviors: internalizing, externalizing, and attentional problems.

Internalizing problems reflect an internally distorted or inconsistent emotional state that interferes with the ability to function properly. Examples include anxiety, depression, and social withdrawal (Lande et al., 2009).

Externalizing problems reflect externally observable discomfort and conflict as a form of negative reaction to the external environment; for example, aggression, conflict with others, and violation of social norms (Lande et al., 2009).

Attentional problems refer to a persistent pattern of inattention and/or hyperactivity-impulsivity that negatively impacts social and academic/occupational activities (American Psychiatric Association, 2013). For instance, behavioral evidence includes difficulty sustaining attention in tasks, following through on instructions, finishing works, seating still, etc.

Conceptual Model Summary. Finally, the conceptual model illustrates the relationship between the enabling attributes of the physical environment and students' behaviors (Figure 1). This model hypothesizes that enabling environmental attributes, including coherence, affordance, control, stimulation, and restoration, will be positively related to adaptive behaviors, measured by conceptual, practical, and social skills, when disability level and types are controlled. Meanwhile, it is assumed that such environmental attributes will have inverse impacts on the occurrence of problem behaviors, including externalizing, internalizing, and attentional problem behaviors.

Expert Judge and Small Group Test

The initial survey was reviewed by eight relevant experts. The review group included four professors in special education, two special education graduates, and two caregivers of people with IDD. As a result of the review, two major changes were made as follows.

Firstly, two separate survey forms were created to represent parents and teachers. This change was made reflecting the comment that these two respondent groups would answer question reflecting different experiences. According to a reviewer, the parent group is likely to answer the survey questions based on their interaction with their children at home as a learning environment, while teacher group is likely to answer the questions considering their experience

with students at school or organizations. So, different wording was necessary to receive accurate answers.

Secondly, the term "people with intellectual disabilities" was changed to "people with intellectual and developmental disabilities (IDD)" throughout the survey. This study considered intellectual disability and autism spectrum disorders (ASD) as a unit of analysis. People with intellectual disabilities do not embrace ASD; rather, the term people with IDD is more appropriate for the selected disability types as guided by the American Association on Intellectual and Developmental Disabilities (AAIDD).

Final Survey Structure

A 10-minute online survey was developed to test this study's conceptual framework based on the P-E fit model. The survey consisted of three rating scales: the Environmental Evaluation (EE), the Performance Measure (PM), and the Brief Problem Monitor (BPM) (Appendix B). The EE was used for measuring the enabling environmental attributes as an independent variable, and the PM and the BPM were used to assess students' targeted adaptive behaviors and problem behaviors, respectively. There were two types of forms according to respondents' relation to the student: Teacher and Parent. The teacher form was used for classroom teachers, counselors, special educators, administrators, or others, and the parent form was displayed for parents or grandparents of people with IDD.

In the first section, the Environmental Evaluation (EE) was developed for this study's purpose to quantify enabling features in students' learning environments. The five environmental constructs – coherence, affordance, control, stimulation, and restoration – were defined by 26 measurable items (Table 12). The items were based on Khare and Mullick's (2008) environmental evaluation items as well as the identified items through the systematic review in

the previous section (Table 5 and Table 10). The presence of each item (enabling attribute) in the students' learning environments was scored on a five-point Likert scale **(**1 – never 2- rarely 3- sometimes 4- often 5- always). Cronbach's alpha was used to check internal consistency (reliability), and factor analyses were used to test dimensionality (construct validity) (Table 21).

Table 12

Environmental Evaluation (EE) – Teacher

Constructs	**Measures**
Coherence (6) clarity or comprehensibility of building elements and form	**Routine**: Spaces are sequenced by logical order (e.g. a sequence of activities, routines, sensory characteristics, etc.).
	Efficient Circulation: The students' major routes are direct and short (e.g. from entrance to a classroom, a classroom to restrooms, external play areas, etc.).[1]
	Compartmentalization: Each room (or area) has a single function and is defined with a clear boundary.
	Visual Access: Clear visual access for the student is provided (e.g. use of half-walls, preview windows, open shelves/floorplan, etc.).[2]
	Repetition: There are navigational aids present for the student in a cohesive way (e.g. consistent color coding, graphics, etc.).[3]
	Building Shape: The building's shape that the classroom space is located is simple (e.g. the minimized number of floors, corners, intersections, and length of hallways).[4]
Affordance (6) a quality that makes users predict the functions of object or space	**Environmental Cue**: The environmental cues – e.g. signage, landmarks, visual instructions, etc. – are appropriately located at decision-making points, where the activities are to be performed.[5]
	Non-text: Non-text components are used in environmental cues (e.g. concrete figures, numbers, symbols, colors, etc.)
	Text: Text is written at a lower secondary education level with a recognizable font (sanserif font), size and spacing.
	Contrast: Color contrast is apparent between background and content, or between colors in the content.
	Symbols: Signage/labels with symbols (e.g. arrows) are designed and placed in a way that enables a direct, clear interpretation for the student.[6]
	Highlight: Important signage/labels information is highlighted (e.g. bold text, illumination, perpendicular installation, etc.).

Table 12 (Continued)

Environmental Evaluation (EE) – Teacher

Constructs	Measures
Control (4) a feature that allows users to regulate their exposure to desired surroundings or alther the physical environment.	**Social Area:** Social areas are provided with easy access for the student (e.g. general purpose, dining areas, niche/alcove within corridor, etc.).[7]
	Gross-motor Area: Gross motor skill areas are provided with easy access for the student (e.g. large open space with high ceilings, slide, swing, climbing, etc.).[8]
	Quiet Area: Quiet rooms (or areas) are located separately from the primary social areas while remaining in the proximate distance.
	Personal Space: Expanded personal space is allowed for the student (e.g. wide hallways, workstations, etc.).[9]
Stimulation (5) the amount of sensory information from the surrounding environment that affect human behavior	**Low Arousal (Tactile):** Indoor temperature is consistently controlled.
	Low Arousal (Olfactory): Indoor air quality is consistently controlled.
	Low Arousal (Visual): There is no visual clutter (e.g. excessive colors, patterns, or flickering lighting).
	Low Arousal (Auditory): Noise is controlled by the remote placement of noise sensitive spaces from spaces known to be noise producing.
	Assistive Tech: Assistive technology is used to control the environment (e.g. electrical appliances controller, blind controls devises, virtual assistant, etc.).
Restoration (5) a therapeutical feature of environment that potentially attenuates stress by providing rest, recovery, or comtemplation.	**Multisensory**: Multiple physical setting options are provided for variation in sensory condition and easy access (e.g. sensory rooms; high vs. low stimulus zones; containment vs. openness; with vs. without background sound; etc.).
	Transition: Distinctive sensory zones – e.g. high or low stimulus - are connected with transition areas to recalibrate students' senses.[10]
	Natural Light: The student is provided the opportunity to natural light.[11]
	Natural Scene: The student is provided the opportunity to natural scenes.[12]
	Naturalness: Natural features are found inside of the building (e.g. materials, artwork, plants, etc.).

Note. The marked items were presented in the Parent form as follows:
[1] The child's major routes are direct and short (e.g. from entrance to a classroom, a classroom to restrooms, external play areas, etc.).
[2] Clear visual access for the child is provided (e.g. use of half-walls, preview windows, open shelves/floorplan, etc.).[2]
[3] There are navigational aids present for the child in a cohesive way (e.g. consistent color coding, graphics, etc.).

[4] The building's shape that the study room is located is simple (e.g. the minimized number of floors, corners, intersections, and length of hallways).
[5] The environmental cues – e.g. labels, visual instructions, etc. – are appropriately located at decision-making points, where the activities are to be performed.
[6] Signage/labels with symbols (e.g. arrows) are designed and placed in a way that enables a direct, clear interpretation for the child.
[7] Social areas are provided with easy access for the child (e.g. general purpose, dining areas, etc.).
[8] Gross motor skill areas are provided with easy access for the child (e.g. large open space with high ceilings, slide, swing, climbing, etc.).
[9] Expanded personal space is allowed for the child (e.g. wide workstations, etc.).
[10] Distinctive sensory zones – e.g. high or low stimulus - are connected with transition areas to recalibrate children's senses.
[11] The child is provided the opportunity to natural light.
[12] The child is provided the opportunity to natural scenes.

In the second section, this study adopted the Performance Measure (PMPA) to measure students' adaptive behaviors and called it the Performance Measure (PM). The PMPA was developed by Khare and Mullick (2008) to quantify an individual's performance of particular tasks and activities in the context of educational settings that has undergone the environmental evaluation.

As Khare and Mullick (2008) guided, the questions in performance measure should be derived from the design parameters in the Environmental Evaluation (EE), based on the assumption that design parameters have impacts on the targeted performances. The 23 items in the PMPA were a basis of the performance measure in this research, however, several items were revised by the following procedure. First, the existing items in PMPA were categorized according to the three constructs: conceptual, practical, and social skills (Tassé et al., 2017). Second, five items were deleted because they were not relevant to this study's scope: design relevant to monitor, maintenance, and safety. Third, five items were excluded as they were included in the next section, the measure of problem behaviors through the BPM. Fourth, two items were added: spatial problem-solving skill under practical skills and following rules under social skills. Finally, the 15 targeted adaptive behavior items were determined in the PM (Table

13). Each item was scored on a three-point Likert scale (0 = Never, 1 = Sometimes, 2 = Always). Cronbach's alpha was used to check internal consistency (reliability), and factor analyses were used to test dimensionality (construct validity) (Table 22).

Table 13

Performance Measure (PM)-Teacher

Constructs	Measurement
Conceptual Skills (4) understanding space/context	Can recognize spaces according to their purpose and activity (e.g. study, leisure, dining areas, etc.) Can recognize intended equipment, supplies, or furniture purpose Can interpret the meaning of the environment's visual cue provision (e.g. restrooms, labels, visual instructions, etc.) Can read and understand information on visual instructions/signage
Practical Skills (6) travel (inside of building), school living, self-care, routine/schedule	Can navigate through the spaces to get to their desired destination (e.g. travel to restrooms, classroom transition, etc.)[1] Can make decisions and solve problems when disoriented in the learning environment Can perform different types of learning activities independently (e.g. academic, vocational, group learning, etc.) Can follow daily scheduled activities independently (e.g. daily tasks, eating, cleaning up, etc.) Can take care of personal needs (e.g. toileting, hygiene, etc.) Can use personal storage properly
Social Skills (5) interpersonal skills, responsibility, coping, leisure/play	Can respect one's own and others' personal spaces while engaged with others Can use designated spaces intended for the purpose of withdrawal in order to cope with emotional behaviors in social situation Can follow classroom rules[2] Can initiate and engage in different types of play (e.g. solitary, parallel, group play, etc.) Can participate in social or recreational activities

Note. The marked items were presented in the Parent form as follows:
[1] Can navigate through the spaces to get to their desired destination (e.g. travel to a restroom, dining area, etc.)
[2] Can follow house rules

In the third section, the presented study used the Brief Problem Monitor (BPM), a component of the Achenbach System of Empirically Based Assessment (ASEBA), to measure problem behaviors. The BPM is an abbreviated version of the Child Behavior Checklist (CBCL),

which is a widely used questionnaire to assess children's behavioral and emotional problems and competencies in diverse settings. The BPM measures 19 items under three higher-order factors of attentional, internalizing, and externalizing problems (Table 14). Each item was scored on a three-point Likert scale (0 = Not True, 1 = Somewhat True, 2 = Very True). High correlations between the CBCL and BPM have been identified for the total score (r = 0.95) and subscales including attention (0.97), internalizing (0.86), and externalizing (0.93) scores (Piper et al., 2014). BPM has demonstrated high reliability (Cronbach's alpha = 0.91), satisfactory for attention (0.87), internalizing (0.78), externalizing (0.86) scales (Piper et al., 2014).

Table 14

The Brief Problem Monitor (BPM)-Teacher

Constructs	Measurement
Attentional Problems	Acts too young for his/her age
	Fails to finish things they start
	Can't concentrate, can't pay attention for long periods of time
	Can't sit still, restless, or hyperactive
	Impulsive or acts without thinking
	Inattentive or easily distracted
Internalizing Problems	Feels worthless or inferior
	Too fearful or anxious
	Feels too guilty
	Self-conscious or easily embarrassed
	Unhappy, sad, or depressed
	Worries
Externalizing Problems	Destroys things belonging to others
	Disobedient at school
	Argues a lot
	Stubborn, sullen, or irritable
	Temper tantrums or hot temper
	Threatens people
	Stereotyped, repetitive, self-stimulatory behaviors (additional item)

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Table 15 summarizes the three measures used in the online survey.

Table 15

Quantitative Survey Instrument

	Environment Evaluation (EE)	**Performance Measure (PM)**	**Brief Problem Monitor (BPM)***
Purpose	To measure enabling attributes in the learning environment (IV)	To measure targeted adaptive behaviors in the learning environment (DV1)	To measure problem behaviors in the learning environment (DV2)
Intended Use	Modification	Modification	Use of existing
Construct (# items)	Coherence (6) Affordance (6) Control (4) Stimulation (5) Restoration (5)	Conceptual (4) Practical (6) Social (5)	Attentional problem (6) Internalizing problems (6) Externalizing problems (7)
Total # of items	26	15	19
Scale	5-Likert	3-Likert	3-Likert
Reliability	Cronbach's alpha	Cronbach's alpha	Cronbach's alpha (Piper et al., 2014)
Validity	Content validity: Theory-based approach and experts' agreement Construct validity: Factor analysis	Content validity: Experts' agreement Construct Validity: Factor analysis	Validity: Correlation to the Child Behavior Checklist (CBCL) (Piper et al., 2014)
Total administration time		Approximately 10 minutes	

Note. IV: independent variable, DV: dependent variable.
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Semi-structured Interview Protocol

The semi-structured interview was designed for future use to further elaborate the quantitative findings on the impacts of the identified environmental design elements on students' behaviors. Interview questions were created according to the quantitative survey structure to synthesize the qualitative and quantitative data in interpreting the results. The initial interview questions are simple enough for people with IDD, letting them answer between easy, moderate, or hard. Once children answer the primary questions, probing questions will be asked. Appendix C presents the interview protocol.

Procedure

Once the University of Oklahoma Institutional Review Board's permission was granted, the research request was sent to the schools, healthcare, and other organizations relevant to the special education services in the United States. If the schools or organizations agreed to send or post the research flyer, a representative person reached out to educators, parents, staff, or any relevant people in their network through their listserv, social media, or webpage on behalf of the researcher. A recruitment flyer was also circulated among the education students who were pursuing degrees at the University of Oklahoma by using the college's weekly newsletter. The recruitment flyer led potential participants to the online consent and survey. The recruitment material is presented in Appendix D.

In the second phase of the recruitment, the flyer was distributed to South Korea, and incentives were introduced. In South Korea, every respondent received 3,000 Korean won (KRW), approximately 2.7 U.S. dollars (USD), once they finished the survey. For the United States participants, the respondents were entered to win one of thirty $10 gift cards.

Data Analysis

Multiple linear regression was used to access the associations between environmental attributes and adaptive behavior (Research Question #1) and problem behaviors (Research Question #2). Statistical Package for the Social Sciences (SPSS) version 27 in combination with R packages were used for statistical computing.

To deal with missing data, the Little's missing completely at random (MCAR) test was conducted by the expectation-maximization (EM) method using SPSS. Once the test indicated that missing data were MCAR, different approaches were implemented to address missing data according to the types of analyses. Listwise deletion is used for factor analyses, and multiple

imputations were implemented to infer missing data for regression analyses. Multiple imputation method replaced the missing values with a set of plausible, predicted values (Kang, 2013).

Using the collected sample with listwise missing data deletion, confirmatory factor analysis (CFA) and exploratory factor analysis (EFA) were conducted to access dimensionality among the items in the modified questionnaires for this study: the Environmental Evaluation (EE) and the Performance Measure (PM). Factor analyses were run using the R package: lavaan and psych (Rosseel, 2012). If the initial CFA did not confirm the theorized model, the exploratory factor analysis (EFA) was conducted to find a new model that explains better about the collected data's dimensionality. Minimum residual (MinRes) factoring and oblique rotation (oblimin) method were used for EFA. All factors with an eigenvalue greater than 1 and with a factor loading above 0.4 were retained. A scree plot and theoretical consideration were also examined to determine the number of informative factors to retain.

Multiple linear regression was conducted using the imputed dataset. Multiple linear regression is modeled to assess how the design elements predict students' performance: $Y = b1*x1 + b2*x2 + b3*x3 + \ldots + c$, where Y = students' behaviors, c = constant (including the error term), b = regression coefficients, and x = environmental attributes.

Before testing regression model, the assumptions of multiple regression were assessed regarding linearity, homoscedasticity, normality, and multicollinearity (Osborne & Waters, 2002). Linearity and homoscedasticity were assessed by examination of a scatter plot and the standardized residuals plot. Normality was inspected by the P-P plot, histogram, and outliars. Any observations with Cook's Distance values over 1 were regarded as outliers. Multicollinearity was assessed using Variance Inflation Factors (VIF) and tolerance scores. VIF over 10 and below 0.2 were regarded as the presence of multicollinearity (Menard, 2009).

Once the assumptions were met, stepwise multiple regression was computed using SPSS. The F-test and t-test were reported to show significance of independent variables. The multiple correlation coefficient, R-squared, was used to determine how much the dependent variable can be explained by the set of independent variables, and the beta coefficients was used to determine the degree of prediction for each independent variable (*Statistics Solutions*, 2013). To ensure statistical power of the regression models, a power analysis was conducted using the software package, *G*Power*. The power level was computed with a medium effect size (f^2) of 0.15 and an alpha level of 0.05 (Cohen, 1988).

Results

The presented study aimed to answer to what extent a set of design factors predict adaptive behaviors and problem behaviors of people with intellectual and developmental disabilities (IDD). Multiple regression was used to assess the association between the physical environment attributes and behavioral outcomes. This section describes the collected sample, followed by the results of descriptive statistics, missing data analysis, factor analysis, and multiple imputation regression.

Description of Sample

A total sample of 219 educators, caregivers, and service providers were recruited from the United States and South Korea between February 17 and March 24, 2021. The research flyer was circulated via relevant organizations' listserv, websites and social media. The participants were recruited on a voluntary basis. Removing 50 incomplete surveys and one refusal to consent, the total sample was reduced to 168. Of the 168 respondents used in the analysis, 139 people (82.7%) were from South Korea and 29 people (17.3%) from the United States. The participants consisted of special educators (64.3%), administrators (17.9%), parents (6.5%), counselors (3.0%), classroom teachers (1.2%), and others (6.0%). Others included special education coordinators, consultant teachers, transition specialists, and therapists. Among the participants other than parents, they had experience working with people with IDD for 15 years and more (29.2%), 10 to 15 years (16.7%), 5 to 10 years (17.3%), 1 to 5 years (26.8%), and less than 1 year (1.8%). The survey also collected the demographic information about people with IDD whom the respondents have interacted with. Their age range were between 14 and 18; specifically, 14 (26.2%), 15 (16.7%), 16 (11.3%), 17 (14.3%), and 18 (28.0%). Males consisted of 70.8 %, and females were 22.0%. They had been identified with Autism Spectrum Disorders

(ASD), intellectual disability, or both. The majority of educational setting was a separate special education school (41.7%), separate special education class (29.8%), and service provider locations (7.7%). The characteristics of the sample are illustrated in Table 16.

Table 16

Characteristics of Participants, n = 168

Respondents' Demographic Information			
Nationality			
Valid	South Korea	139	82.7
	United States	29	17.3
	Total	168	100.0
Relation			
Valid	Special educator	108	64.3
	Classroom Teacher	2	1.2
	Counselor	5	3.0
	Administrator	30	17.9
	Parents	11	6.5
	Grandparents	1	.6
	Others	10	6.0
	Total	167	99.4
Missing	System	1	.6
Total		168	100.0
Gender			
Valid	Male	56	33.3
	Female	105	62.5
	Prefer not to say	1	.6
	Total	162	96.4
Missing	System	6	3.6
Total		168	100.0
Work period, if not parents or grandparents			
Valid	Less than 1 year	3	1.8
	1 year to less than 5 years	45	26.8
	5 years to less than 10 years	29	17.3
	10 years to less than 15 years	28	16.7
	15 years and more	49	29.2
	Total	154	91.7
Missing	System	14	8.3
Total		168	100.0

Table 16 (Continued)

Characteristics of Participants, n = 168

Student Demographic Information			
Age			
Valid	14	44	26.2
	15	28	16.7
	16	19	11.3
	17	24	14.3
	18	47	28.0
	Total	162	96.4
Missing	System	6	3.6
Total		168	100.0
Gender			
Valid	Male	119	70.8
	Female	37	22.0
	Prefer not to say	7	4.2
	Total	163	97.0
Missing	System	5	3.0
Total		168	100.0
Disability Type (All that apply)			
Valid	Intellectual Disability	121	72.0
	Autism Spectrum Disorders (ASD)	84	50.0
	Others	7	4.2
Disability Level			
Valid	Mild Intellectual Disability (Approximate IQ range 50 - 69)	85	50.6
	Moderate Intellectual Disability (Approximate IQ range 36 - 49)	80	47.6
	Total	165	98.2
Missing	System	3	1.8
Total		168	100.0

Table 16 (Continued)

Characteristics of Participants, n = 168

Educational setting			
Valid	Separate Special Education School	70	41.7
	Separate Special Education Class	50	29.8
	Service Provider Location	13	7.7
	Home	8	4.8
	Inside Regular Class	8	4.8
	Residential Facility	6	3.6
	Separate Day Facility	4	2.4
	Correctional facility	4	2.4
	Homebound/Hospital	2	1.2
	Others	1	.6
	Total	166	98.8
Missing	System	2	1.2
Total		168	100.0

Descriptive Statistics and Missing Data Pattern Analysis

The missing data rate and patterns were analyzed for three measures, including the Environmental Evaluation (EE), the Performance Measure (PM), and the Brief Problem Behavior (BPM). There was no complete variable for the EE, the PM, and the BPM items, which means one or more missing data exist for every item. The missing data rate for EE items was 1.8% to 7.1%, and complete cases were 33 out of 168 (19.64%). The missing data rate of PM was between 2.4% and 7.1%, and there were 30 complete cases (17.86%). When it comes to the BPM, the missing data rate was between 5.4% and 26.8%, higher than the other two measures. The majority of items, which missing data rate were higher than 15%, consisted of items measuring internal and external problems. The results of missing data pattern analyses for the EE, the PM, and the BPM are presented in Table 17, 18, and 19, respectively.

Table 17

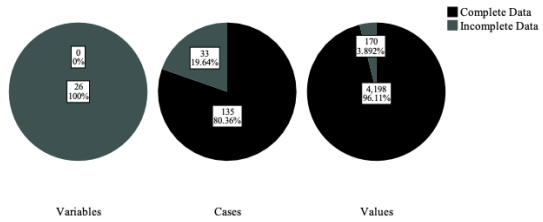
Missing Data Rate and Patterns: Environmental Evaluation (EE)

	Missing				
	N	Percent	Valid N	Mean	Std. Deviation
AssistiveTech	12	7.1%	156	1.8718	1.08192
Multisensory	10	6.0%	158	2.0380	1.03374
BuildingShape	10	6.0%	158	2.5380	1.26005
Transition	9	5.4%	159	1.9874	.99992
Auditory	8	4.8%	160	2.2625	1.08441
QuietArea	8	4.8%	160	2.1250	1.11451
Highlight	8	4.8%	160	2.2187	.97563
Contrast	8	4.8%	160	2.2438	.97611
Olfactory	7	4.2%	161	3.1988	.99260
Naturalness	7	4.2%	161	2.6273	1.13919
GrossMotor	7	4.2%	161	2.1366	1.14290
NonText	7	4.2%	161	2.2857	1.06904
NaturalScene	6	3.6%	162	3.0185	1.06013
SocialArea	6	3.6%	162	2.4506	1.11485
Text	6	3.6%	162	2.4074	.97519
Repetition	6	3.6%	162	2.0370	1.07420
VisualAcc	6	3.6%	162	2.4938	1.05881
Compartment	6	3.6%	162	2.5617	1.03924
Visual	5	3.0%	163	2.8773	1.04097
PersonalSpace	5	3.0%	163	2.6748	1.08231
Symbols	5	3.0%	163	2.2209	1.01242
Tactile	4	2.4%	164	3.2195	.99106
EnvironCues	4	2.4%	164	2.4085	1.02013
Routine	4	2.4%	164	2.4146	.96505
NaturalLight	3	1.8%	165	3.1273	.97633
Circulation	3	1.8%	165	2.6848	.94227

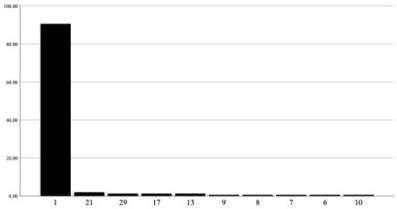
Table 17 (Continued)

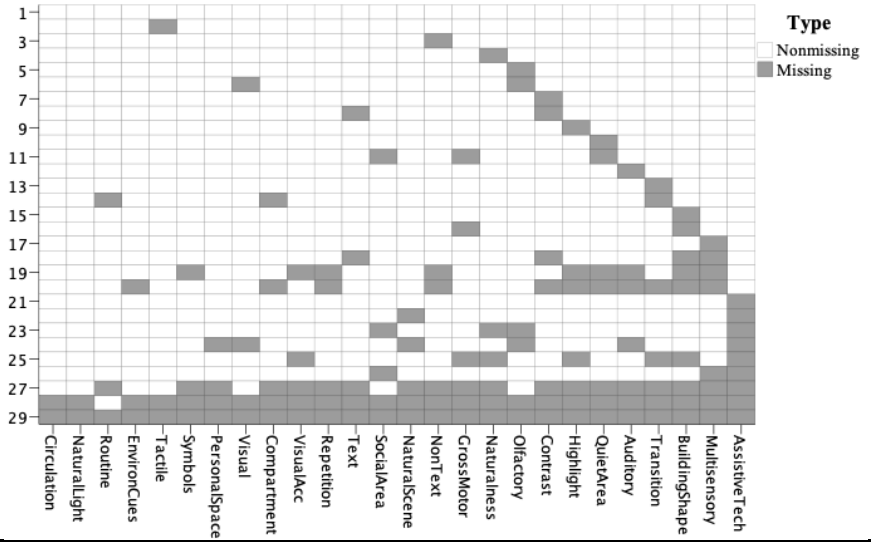
Missing Data Rate and Patterns: Environmental Evaluation (EE)

Overall Summary of Missing Values



Missing Value Patterns[a]





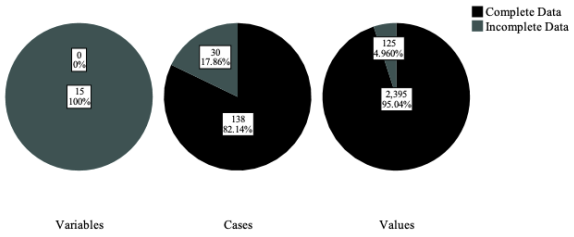
a. The ten most frequently occurring patterns are shown in the chart.

Table 18

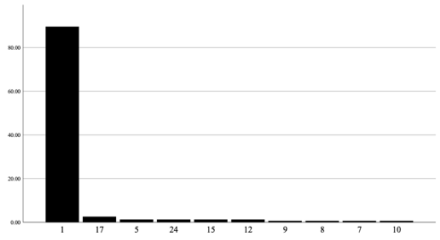
Missing Data Rate and Patterns: Performance Measure (PM)

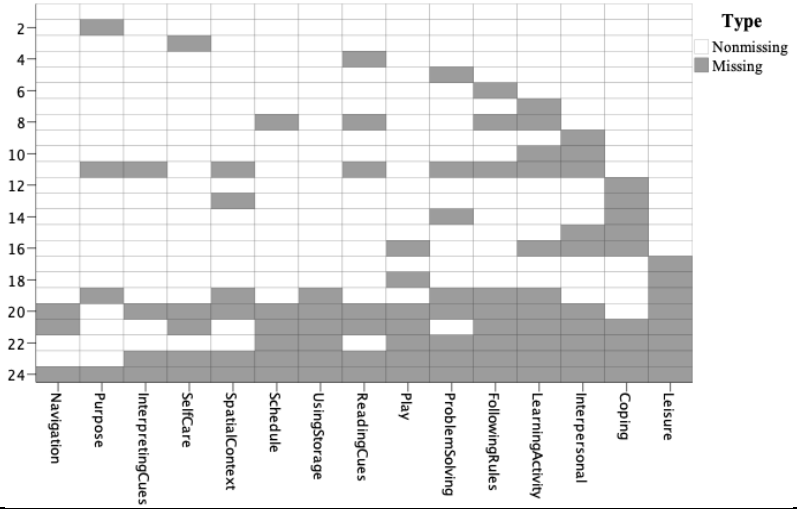
	Missing				
	N	Percent	Valid N	Mean	Std. Deviation
Leisure	12	7.1%	156	1.2308	.68010
Coping	12	7.1%	156	1.0705	.71040
Interpersonal	12	7.1%	156	1.1026	.72894
LearningActivity	12	7.1%	156	1.2372	.69200
FollowingRules	10	6.0%	158	1.3797	.60368
ProblemSolving	10	6.0%	158	1.1456	.65643
Play	8	4.8%	160	1.1500	.71110
ReadingCues	8	4.8%	160	1.2750	.68175
UsingStorage	7	4.2%	161	1.4161	.69425
Schedule	7	4.2%	161	1.2919	.67675
SpatialContext	7	4.2%	161	1.5901	.56427
SelfCare	6	3.6%	162	1.4630	.65122
InterpretingCues	5	3.0%	163	1.3190	.62564
Purpose	5	3.0%	163	1.4785	.62200
Navigation	4	2.4%	164	1.6524	.56040

Overall Summary of Missing Values



Missing Value Patterns[a]





a. The ten most frequently occurring patterns are shown in the chart.

Table 19

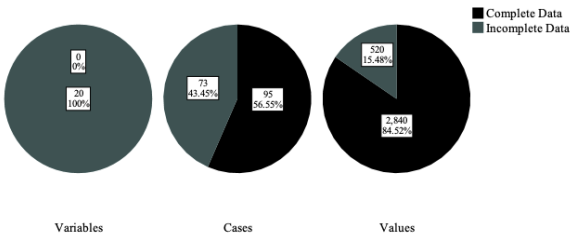
Missing Data Rate: Brief Problem Behavior (BPM)

	Missing				
	N	Percent	Valid N	Mean	Std. Deviation
Guilty	45	26.8%	123	.3821	.59396
Threatens	44	26.2%	124	.6290	.72659
Worries	35	20.8%	133	.6391	.68907
Temper	35	20.8%	133	.8346	.74040
SelfConc	32	19.0%	136	.7059	.66797
Worthless	32	19.0%	136	.4559	.66519
Argues	32	19.0%	136	.7868	.79263
Unhappy	30	17.9%	138	.7174	.70441
DestroysThings	30	17.9%	138	.7681	.76692
Stereotyped	29	17.3%	139	1.1367	.79127
Fearful	24	14.3%	144	.9583	.72782
DisobeyHome	23	13.7%	145	.8966	.73337
Stubborn	22	13.1%	146	1.0000	.72397
DisobeySchl	20	11.9%	148	.8851	.69521
Inattentive	19	11.3%	149	1.2416	.71330
SitsStill	19	11.3%	149	1.1208	.72515
Impulsive	16	9.5%	152	1.1382	.70990
FailsToFinish	13	7.7%	155	1.1871	.68174
Concentrates	11	6.5%	157	1.3949	.62796
ActsYoung	9	5.4%	159	1.2767	.60496

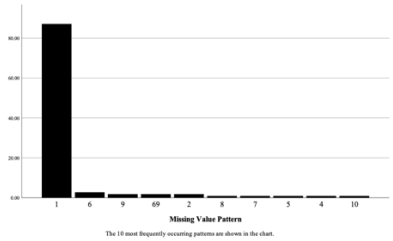
Table 19 (Continued)

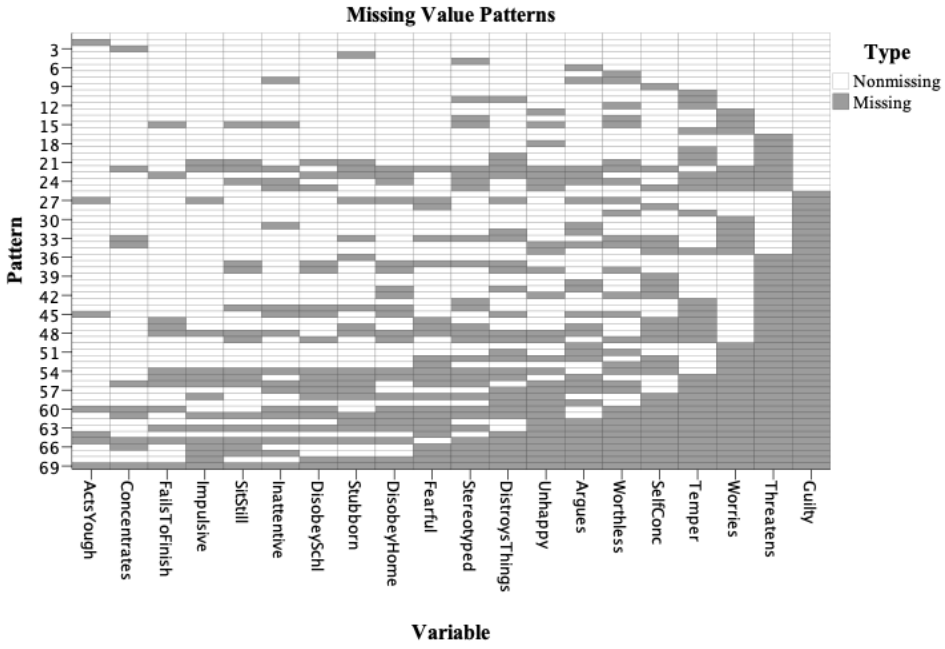
Missing Data Rate: Brief Problem Behavior (BPM)

Overall Summary of Missing Values



Missing Value Patterns[a]





a. The ten most frequently occurring patterns are shown in the chart.

Little's Missing Completely at Random (MCAR) test

To handle the missing data, Little's missing completely at random (MCAR) test was conducted by the expectation-maximization (EM) method using SPSS. The null hypothesis for Little's MCAR, the data are missing completely at random, was tested. All items in the three measures were entered to missing value analysis dialog. The result was not significant (Chi-Square = 5285.937, df = 5176, p = .140), which indicated the data were MCAR. Since the null

hypothesis was not rejected, no patterns existed, and it was safe to listwise delete cases or proceeds with multiple imputations.

Table 20

Expectation-Maximization (EM) Means[a,b]

Routine	2.4047
Circulation	2.6740
Compartment	2.5400
Transition	1.9656
VisualAcc	2.4925
BuildingShape	2.4774
EnvironCues	2.3848
Repetition	1.9977
NonText	2.2585
Text	2.3892
Contrast	2.2210
Symbols	2.1953
Highlight	2.1758
Multisensory	1.9999
QuietArea	2.1006
SocialArea	2.4570
GrossMotor	2.1282
NaturalLight	3.1274
NaturalScene	2.9905
Naturalness	2.6123
PersonalSpace	2.6774
Tactile	3.2166
Olfactory	3.1798
Visual	2.8740
Auditory	2.2596
AssistiveTech	1.8721
Navigation	1.6467
ProblemSolving	1.1361
SpatialContext	1.5784
Purpose	1.4755
LearningActivity	1.2072
Schedule	1.2809
InterpretingCues	1.3070

Table 20 (Continued)

Expectation-Maximization (EM) Means[a,b]

ReadingCues	1.2479
SelfCare	1.4476
UsingStorage	1.4056
Interpersonal	1.0823
Coping	1.0320
FollowingRules	1.3648
Play	1.1372
Leisure	1.2090
ActsYough	1.2581
Argues	.7932
FailsToFinish	1.1715
Concentrates	1.3955
SitStill	1.1133
DistroysThings	.7436
DisobeyHome	.8670
DisobeySchl	.8596
Worthless	.4316
Impulsive	1.1184
Fearful	.9454
Guilty	.3992
SelfConc	.6936
Inattentive	1.2161
Stubborn	.9893
Temper	.8012
Threatens	.6631
Unhappy	.7199
Worries	.6151
Stereotyped	1.0880
Nationality	.17
StudentAge	3.02
StudentGender	1.34
DisabilityLevel	2.48
Duration	3.49

a. Little's MCAR test: Chi-Square = 5285.937, DF = 5176, Sig. = .140
b. The EM algorithm failed to converge in 25 iterations.

Factor Analysis

Using the original and entire sample of 168 participants with listwise missing data deletion, confirmatory (CFA) and exploratory factor analysis (EFA) were conducted to access dimensionality among items in the modified questionnaires for this study: the Environmental Evaluation (EE) and the Performance Measure (PM). Factor analyses were run using the R package: lavaan and psych (Rosseel, 2012). CFA was initially used because the theoretical framework underlying the instrument was well understood for both questionnaires. The model fit indices and cutoff value were chosen to determine the degree of fit between the model and the data, in other words, whether or not the hypothesized construct of the modified instrument was sensible. According to Hu and Bentler's (1999) recommendation, the following criteria were used to evaluate the adequacy of the model: comparative fit index (CFI) > 0.95 in combination with the root-mean-square error of approximation (RMSEA) < 0.06 or the standardized root-mean-square residual (SRMR) < 0.08. When it comes to reliability assessment, coefficient alpha greater than 0.80 was considered acceptable.

If the data did not fit the model proposed in the CFA, the exploratory factor analysis (EFA) was conducted to understand underlying patterns in the collected data, identify potentially problematic items, and ultimately, suggest a new factor solution with a better dimensionality explained. Minimum residual (MinRes) factoring and oblique rotation (oblimin) method were used for EFA. All factors with an eigenvalue greater than 1 were retained. Factor loading cutoff was determined at 0.4. A scree plot and theoretical consideration were also examined to determine the number of informative factors to retain. Once the factor model is confirmed, the sum scores were used to interpret the data as representing each factor.

The followings commands were entered for CFA and EFA using R.

```
#CFA
factor.model <- ‘ f =~ q01 + q02 + q03 …’
fit <- cfa(factor.model, data=data)
summary(fit, fit.measures=TRUE)
#EFA
parallel <- fa.parallel(items, fm = 'minres', fa = 'fa') #1 factor
factor <- fa(items, nfactors = 4,rotate = "oblimin",fm="minres")
print(factor$loadings,cutoff = 0.4)
fa.diagram(factor)
```

The results of factor analysis for EE and PM are presented in Tables 20 and 21, respectively.

Factor Analysis Results of Environmental Evaluation (EE)

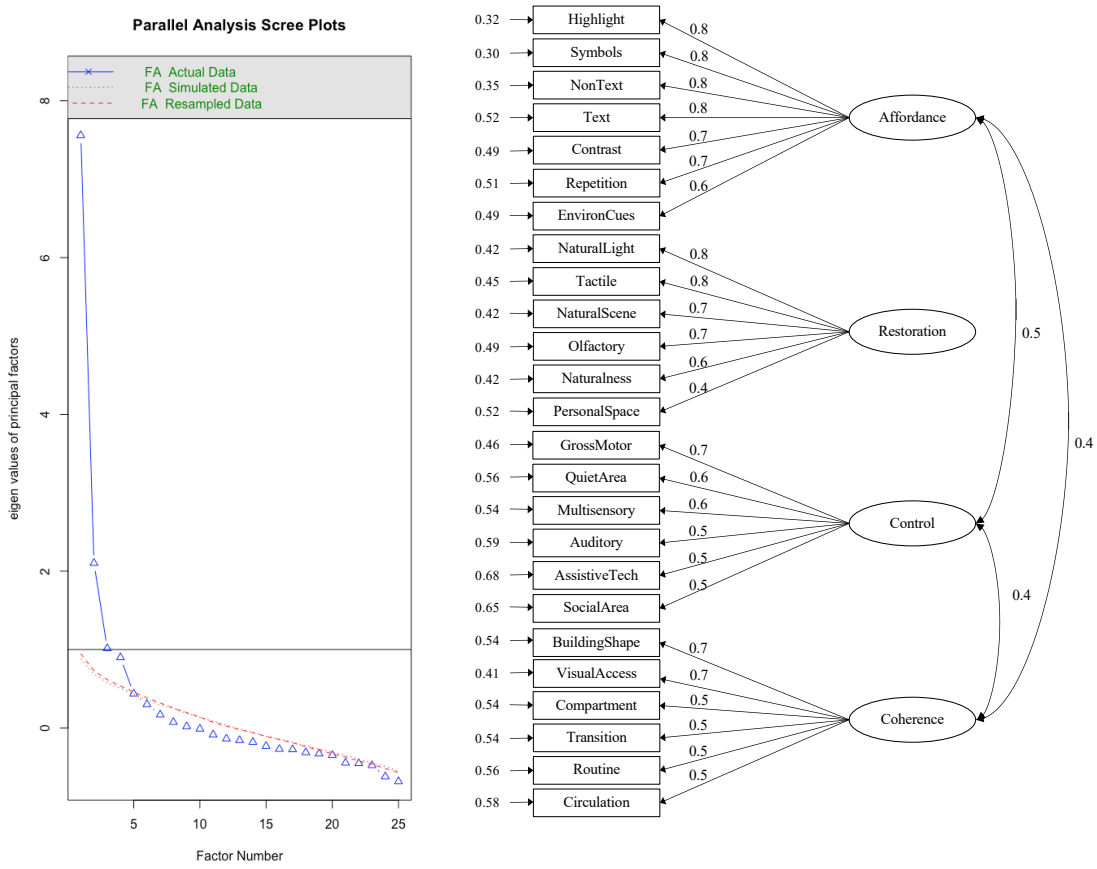
Initial CFA was conducted for the five-factor solution. The Goodness-of-fit test was significant ($\chi^2 = 335.192$, df = 24, p = .000). Additional model fit indices indicated that the data did not support the five-factor model. Specifically, CFI was 0.710, RMSEA was 0.106, and SRMR was 0.139, suggesting misfit. Because the results from the CFA indicated that, in the collected sample, the data did not support the hypnotized five-factor model, an EFA was proceeded to explore the factor structure of the data.

In EFA, parallel analysis based on eigenvalues indicated four components (Figure 5). The four-factor solution was examined whether the factors were theoretically explained. The items under the stimulation factor were inserted into the other factors; Specifically, Tactile and Olfactory were included in the restoration component, and items of Auditory and AssistiveTech were to the control component. One item under stimulation showed relatively lower factor

loading of 0.341: There is no visual clutter (e.g. excessive colors, patterns, or flickering lighting). Since the visual factor was also addressed in the other item of VisualAccess, which measured "clear visual access for the student is provided (factor loading = 0.679)," the Visual item with factor loading lower than 0.4 was removed.

Figure 5

Exploratory Factor Analysis: Environmental Evaluation (EE) Items



In conclusion, the CFA and EFA indicated that the original five-dimensional scale was not supported in the collected sample. Instead, both the empirical data and theoretical consideration indicated four-factor subscales for the environmental evaluation (EE): affordance, restoration, control, and coherence, (Table 21). Seven items were used to measure affordance (Eigenvalue = 4.41, Variance = 0.17), six for restoration (Eigenvalue = 3.28, Variance = 0.13), six for control (Eigenvalue = 2.85, Variance = 0.11), and six for coherence (Eigenvalue = 2.49,

Variance = 0.10). The revised 25 items with four-component model explained 51% of the total variance. Each of these variables represents the pool of enabling environmental attributes (Cronbach's Alpha = .897).

Table 21

Factor Analysis Results of the Environmental Evaluation (EE) Items (n = 135)

Factor name/scale items	Factors			
	1	2	3	4
Factor 1. Affordance				
Highlight: Important signage/labels information is highlighted (e.g. bold text, illumination, perpendicular installation, etc.).	.791			
Symbols: Signage/labels with symbols (e.g. arrows) are designed and placed in a way that enables a direct, clear interpretation for the student.	.779			
Non-text: Non-text components are used in environmental cues (e.g. concrete figures, numbers, symbols, colors, etc.)	.776			
Text: Text is written at a lower secondary education level with a recognizable font (sanserif font), size and spacing.	.768			
Contrast: Color contrast is apparent between background and content, or between colors in the content.	.708			
Repetition: There are navigational aids present for the student in a cohesive way (e.g. consistent color coding, graphics, etc.).	.668			
Environmental Cue: The environmental cues – e.g. signage, landmarks, visual instructions, etc. – are appropriately located at decision-making points, where the activities are to be performed.	.626			
Factor 2. Restoration				
Natural Light: The student is provided the opportunity to natural light.		.763		
Low Arousal (Tactile): Indoor temperature is consistently controlled.		.757		
Natural Scene: The student is provided the opportunity to natural scenes.		.740		
Low Arousal (Olfactory): Indoor air quality is consistently controlled.		.715		
Naturalness: Natural features are found inside of the building (e.g. materials, artwork, plants, etc.).		.574		
Personal Space: Expanded personal space is allowed for the student (e.g. wide hallways, workstations, etc.).		.445		

Table 21 (Continued)

Factor Analysis Results of the Environmental Evaluation (EE) Items (n = 135)

Factor name/scale items	Factors			
	1	2	3	4
Factor 3. Control				
Gross-motor Area: Gross motor skill areas are provided with easy access for the student (e.g. large open space with high ceilings, slide, swing, climbing, etc.).			.693	
Quiet Area: Quiet rooms (or areas) are located separately from the primary social areas while remaining in the proximate distance.			.633	
Multisensory: Multiple physical setting options are provided for variation in sensory condition and easy access (e.g. sensory rooms; high vs. low stimulus zones; containment vs. openness; with vs. without background sound; etc.).			.577	
Low Arousal (Auditory): Noise is controlled by the remote placement of noise sensitive spaces from spaces known to be noise producing.			.500	
Assistive Tech: Assistive technology is used to control the environment (e.g. electrical appliances controller, blind controls devises, virtual assistant, etc.).			.485	
Social Area: Social areas are provided with easy access for the student (e.g. general purpose, dining areas, niche/alcove within corridor, etc.).			.453	
Factor 4. Coherence				
Building Shape: The building's shape that the classroom space is located is simple (e.g. the minimized number of floors, corners, intersections, and length of hallways).				.719
VisualAccess: Clear visual access for the student is provided (e.g. use of half-walls, preview windows, open shelves/floorplan, etc.).				.679
Compartmentalization: Each room (or area) has a single function and is defined with a clear boundary.				.537
Transition: Distinctive sensory zones – e.g. high or low stimulus - are connected with transition areas to recalibrate students' senses.				.496
Routine: Spaces are sequenced by logical order (e.g. a sequence of activities, routines, sensory characteristics, etc.).				.479
Circulation: The students' major routes are direct and short (e.g. from entrance to a classroom, a classroom to restrooms, external play areas, etc.).				.453

Table 21 (Continued)

Factor Analysis Results of the Environmental Evaluation (EE) Items (n = 135)

	Factors			
	1	**2**	**3**	**4**
Sum of Squared Loadings	4.41	3.28	2.85	2.49
Proportion Variance	0.17	0.13	0.11	0.10
Proportion Explained	0.34	0.25	0.22	0.19

Note. Rotation method: oblimin. Cronbach's Alpha = .897

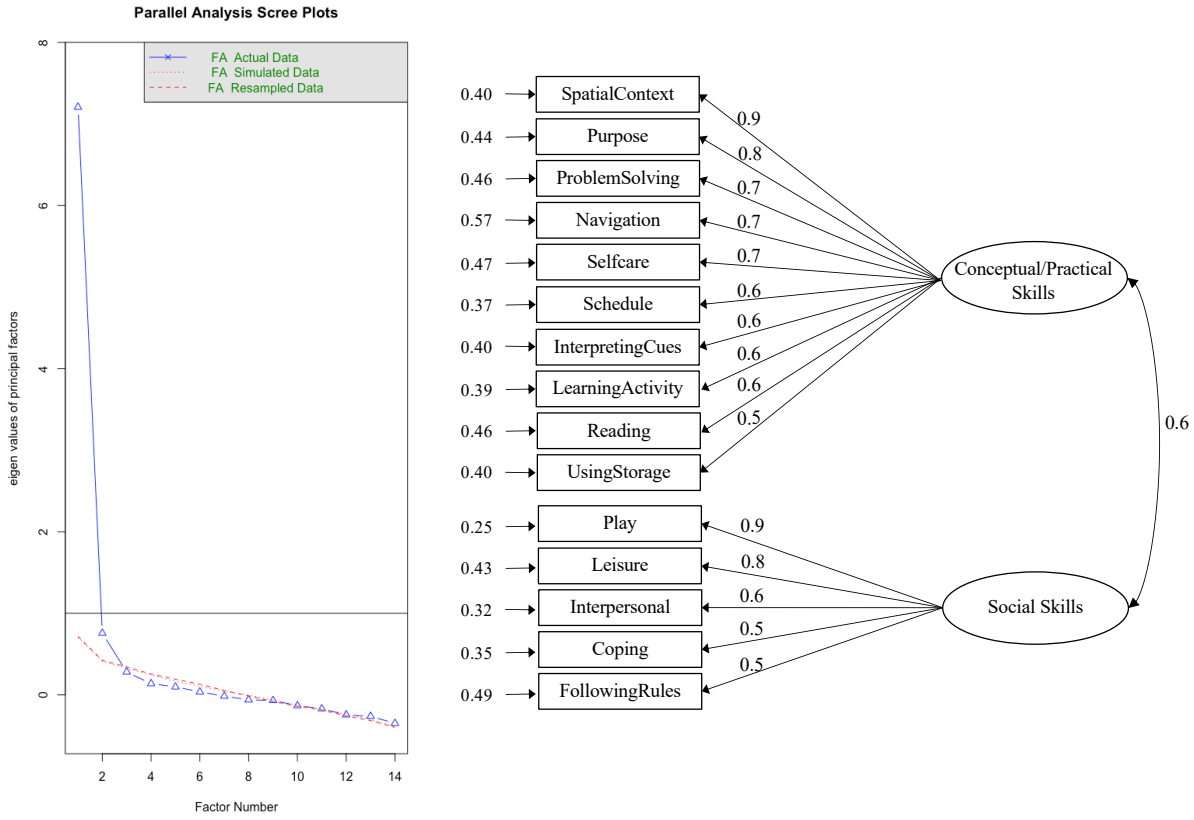
Factor Analysis Results of Performance Measure (PM)

Next, the CFA is used to analyze the dimensionality of the Performance Measure (PM). Initial CFA was conducted for the three-factor solution as hypothesized. The chi-square test of model fit was significant ($\chi^2 = 128.677$, df = 14, p = .000), and model fit indices indicated that the data did not support the three-factor model (CFI = 0.896, RMSEA = 0.109, SRMR = 0.056). As the original three-dimensional scale was not supported in the collected sample, an EFA proceeded.

The ratings on the fifteen PM items were submitted to EFA. Parallel analysis of the scree plot suggested two factors (Figure 6). As the results of EFA, the conceptual and practical skills were combined as one component, and the social skill remained as the initial hypothesized model was. All items were retained since their pattern coefficients were above 0.05. The total variance explained was 59%.

Figure 6

Exploratory Factor Analysis: Performance Measure (PM) Items



In summary, the results from factor analyses did not confirm the proposed three-factor scale for use with people with intellectual and developmental disabilities. Instead, the results indicated two-factor subscales for the Performance Measure (PM): conceptual/practical and social skills (Table 21). Nine items were used to measure conceptual/practical (Eigenvalue = 4.74, Variance = 0.34), five for social skills (Eigenvalue = 3.42, Variance = 0.24). Each of these variables represents the pool of adaptive behaviors (Cronbach's Alpha = .942).

Table 22

Factor Analysis Results of the Performance Measure (PM) Items (n = 138)

Factor name/scale items	Factors	
	1	2
Factor 1. Conceptual/Practical Skills		
SpatialContext. Can recognize spaces according to their purpose and activity (e.g. study, leisure, dining areas, etc.)	.866	
Purpose. Can recognize intended equipment, supplies, or furniture purpose	.764	
ProblemSolving. Can make decisions and solve problems when disoriented in the learning environment	.749	
Navigation. Can navigate through the spaces to get to their desired destination (e.g. travel to restrooms, classroom transition, etc.)	.718	
SelfCare. Can take care of personal needs (e.g. toileting, hygiene, etc.)	.686	
Schedule. Can follow daily scheduled activities independently (e.g. daily tasks, eating, cleaning up, etc.)	.608	
InterpretingCues. Can interpret the meaning of the environment's visual cue provision (e.g. restrooms, labels, visual instructions, etc.)	.604	
Reading. Can read and understand information on visual instructions/signage	.557	
LearningActivity. Can perform different types of learning activities independently (e.g. academic, vocational, group learning, etc.)	.565	
UsingStorage. Can use personal storage properly	.500	
Factor 2. Social Skills		
Play. Can initiate and engage in different types of play (e.g. solitary, parallel, group play, etc.)		.899
Leisure. Can participate in social or recreational activities		.779
Interpersonal: Can respect one's own and others' personal spaces while engaged with others		.617
Coping. Can use designated spaces intended for the purpose of withdrawal in order to cope with emotional behaviors in social situation		.529
FollowingRules. Can follow classroom/house rules		.518
Sum of Squared Loadings	5.40	3.39
Proportion Variance	0.36	0.23
Proportion Explained	0.61	0.39

Note. Rotation method: oblimin. Cronbach's Alpha = .942.

Multiple Imputation Regression

Multiple Imputation

For regression analyses, this study dealt with missing data using multiple imputations that Rubin (1987) proposed as a method to generate consistent inferences from the original dataset. SPSS was used to multiple impute data by default and the imputation number of five was entered (Rubin, 1987). The SPSS's pooling method is the average of imputed individuals' results and is further illustrated in SPSS Statistics Algorithms (SPSS Inc., 2011, pp 603 - 607).

Multiple Regression Assumptions

Before conducting regression analyses, the new imputed dataset was checked if the following multiple regression assumptions were met (Osborne & Waters, 2002).

- Linearity: The relationship between the independent and dependent variables is linear. This study checked linearity by analyzing scatterplots.
- Normality: The values of the residuals are normally distributed. This study inspected the P-P plot, histogram, and outliers. This study considers Cook's Distance values over 1 as an influential case biasing the proposed model.
- Reliability: The covariate is reliably measured. This study considers Cronbach alphas of 0.8 as reliable and avoids a Type II error.
- Homoscedasticity: The variance of errors is constant among independent variables. This study scanned if the plot of standardized residuals is randomly scattered around the horizontal line. A bowtie or fan shape is considered increasing the possibility of a Type I error.

- Independent Residuals: The values of the residuals are independent. This study considered this assumption met when the Durbin-Watson value is close to 2. The values below 1 and above 3 were regarded as invalid.
- No Multicollinearity: There is no multicollinearity in the dataset. This study diagnosed multicollinearity when VIF scores are above 10, and tolerance scores are below 0.2.

Stepwise Regression

Using the new imputed data, multiple linear regression was conducted to assess how the design attributes predict adaptive and problem behaviors of students with intellectual and developmental disabilities (IDD). Based on the proposed theoretical model, further testable hypotheses were stated reflecting the changes in subscales after the factor analyses.

H1. Among people with IDD, a set of enabling design features will positively predict adaptive behaviors.

H1a. Among people with IDD, domains of environmental attributes (affordance, restoration, control, and coherence) will positively predict conceptual/practical skills.

H1b. Among people with IDD, domains of environmental attributes (affordance, restoration, control, and coherence) will positively predict social skills.

H2. Among people with IDD, a set of enabling design features will inversely predict problem behaviors.

H2a. Among people with IDD, domains of environmental attributes (affordance, restoration, control, and coherence) will inversely attentional problems.

H2b. Among people with IDD, domains of environmental attributes (affordance, restoration, control, and coherence) will inversely predict internalizing problems.

H2c. Among people with IDD, domains of environmental attributes (affordance, restoration, control, and coherence) will inversely predict externalizing problems.

Independent variables were entered into stepwise regression models along with control variables, including nationality, student age, student gender, disability level, and duration. Among the suggested models, this study reports a model that shows a higher R squared value, at the same time, consistently appeared in the original, imputed, and pooled dataset. The stated report is based on the pooled data, but all results from original data, imputed data, and the pooled are available in the results tables for comparison. Since SPSS does not provide pooled F and p values, R package miceadd was supplementally used to compute approximation based on χ^2 statistics (Grund et al., 2016). For estimation of the pooled R square and adjusted R square values, R package miceadds was used, which calculation is based on the Fisher z-transformation (Harel, 2009; Rubin, 1987).

Hypotheses Testing

H1. Among people with IDD, a set of enabling design features will positively affect adaptive behaviors.

As a result of stepwise regression analysis, the following variables were removed: nationality, student age, student gender, and duration. Accordingly, two independent variables were entered in the Environ-Adaptive Behavior model: environmental attributes and disability level.

The result of regression analysis depicted significant relationships at the 0.01 level, which accepted Hypothesis 1 (H1). There was a significant relationship between environmental

attributes, disability level, and adaptive behaviors (F (2, 90.13) = 25.363, R^2 = 0.278, p = .000) (Table 26, 27). The result showed that environmental attributes (β = .145) and disability level (beta = -5.881) were significant predictors of students' adaptive behaviors, where environmental attributes are measured by the Environment Evaluation (EE), and disability level is coded as 1 = mild disability, 2 = moderate disability (Table 28). This result indicated that the more frequent is the presence of environmental attributes listed the EE, the more frequent is the occurrence of adaptive behaviors listed in the Performance Measure (PM). Additionally, more frequent adaptive behaviors occur as disability level changes from moderate to mild disability.

Table 23

Environ-Adaptive Behavior Model Summary[ab]

Imputation Number	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
Original data	.594[a]	.352	.341	5.91180	1.907
1	.499[a]	.249	.240	6.44675	2.015
2	.558[a]	.311	.303	6.29860	1.931
3	.530[a]	.281	.272	6.37913	1.990
4	.547[a]	.299	.290	6.23741	2.017
5	.513[a]	.263	.254	6.35440	1.963

Pooled R square = 0.278, adjust R square = 276
a. Predictors: (Constant), DisabilityLevel, EnvironAttributes
b. Dependent Variable: AdaptiveBehavior

Table 24

Environ-Adaptive Behavior Model ANOVA[a]

Imputation Number		Sum of Squares	df	Mean Square	F	Sig.
Original data	Regression	2129.854	2	1064.927	30.471	.000[b]
	Residual	3914.328	112	34.949		
	Total	6044.183	114			
1	Regression	2275.397	2	1137.698	27.374	.000[b]
	Residual	6857.502	165	41.561		
	Total	9132.899	167			
2	Regression	2957.884	2	1478.942	37.279	.000[b]
	Residual	6545.946	165	39.672		
	Total	9503.830	167			
3	Regression	2618.794	2	1309.397	32.177	.000[b]
	Residual	6714.385	165	40.693		
	Total	9333.179	167			
4	Regression	2734.591	2	1367.296	35.144	.000[b]
	Residual	6419.379	165	38.905		
	Total	9153.970	167			
5	Regression	2373.799	2	1186.900	29.394	.000[b]
	Residual	6662.445	165	40.378		
	Total	9036.244	167			

Pooled F(2, 90.13) = 25.363, p = .000

a. Dependent Variable: AdaptiveBehavior

b. Predictors: (Constant), DisabilityLevel, EnvironAttributes

Table 25

Environ-Adaptive Behavior Model Coefficients[a]

Imputation Number		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics				
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF[b]	FMI[c]	RIV[d]	RE[e]
Original data	(Constant)	18.855	4.086		4.615	.000					
	EnvironAttributes	.228	.041	.424	5.540	.000	.987	1.013			
	DisabilityLevel	-5.382	1.112	-.371	-4.842	.000	.987	1.013			
1	(Constant)	23.912	3.298		7.251	.000					
	EnvironAttributes	.144	.032	.303	4.493	.000	.997	1.003			
	DisabilityLevel	-5.514	.978	-.381	-5.638	.000	.997	1.003			
2	(Constant)	25.233	3.258		7.744	.000					
	EnvironAttributes	.150	.031	.313	4.807	.000	.986	1.014			
	DisabilityLevel	-6.132	.935	-.427	-6.560	.000	.986	1.014			
3	(Constant)	25.744	3.332		7.726	.000					
	EnvironAttributes	.142	.031	.301	4.551	.000	.994	1.007			
	DisabilityLevel	-6.170	.992	-.412	-6.218	.000	.994	1.007			
4	(Constant)	25.243	3.271		7.717	.000					
	EnvironAttributes	.152	.031	.320	4.886	.000	.993	1.007			
	DisabilityLevel	-6.165	.964	-.418	-6.395	.000	.993	1.007			
5	(Constant)	24.198	3.337		7.252	.000					
	EnvironAttributes	.137	.031	.294	4.357	.000	.982	1.018			
	DisabilityLevel	-5.424	.956	-.383	-5.675	.000	.982	1.018			
Pooled	(Constant)	24.866	3.407		7.299	.000			.064	.066	.987
	EnvironAttributes	.145	.032		4.516	.000			.044	.045	.991
	DisabilityLevel	-5.881	1.050		-5.601	.000			.165	.184	.968

Dependent Variable: AdaptiveBehavior
a. Variance Inflation Factors
b. Fraction Missing Information
c. Relative Increase Variance
d. Relative Efficiency

H1a. Among people with IDD, domains of environmental attributes will positively affect conceptual/practical skills.

In the Environ-Conceptual/Practical Skill model, the seven variables, including nationality, student age, student gender, duration, affordance, control, coherence, were removed, and two independent variables were entered: restoration and disability level.

The result of regression analysis showed significant relationships at the 0.01 level, which accepted Hypothesis 1a ($F (2, 383.04) = 31.77$, $R^2 = 0.301$, $p = .000$) (Table 26, 27). The conceptual/practical skills were predicted by the equation, 17.631 + .353(Restoration) – 4.101(DisabilityLevel) (Table 28). Restorative features were measured by the sum score of NaturalLight, Tactile, NaturalScene, Olfactory, Naturalness, and PersonalSpace items in the Environment Evaluation (EE), and disability level was coded as 1 = mild disability, 2 = moderate disability. This result indicated that the presence of such restorative features in the environment was relevant to more frequent occurrence of conceptual/practical skills.

Table 26

Environ-Conceptual/Practical Skill Model Summary[ab]

Imputation Number	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
Original data	.588[a]	.346	.337	4.03802	1.862
1	.526[a]	.276	.268	4.21950	1.999
2	.564[a]	.318	.310	4.28524	1.899
3	.542[a]	.293	.285	4.27422	1.940
4	.554[a]	.307	.298	4.15778	1.989
5	.540[a]	.292	.283	4.20906	1.883

Pooled R square = 0.301, adjust R square = 0.300

a. Predictors: (Constant), DisabilityLevel, Restoration
b. Dependent Variable: ConceptualPractical

Table 27

Environ-Conceptual/Practical Skill Model ANOVA[a]

Imputation Number		Sum of Squares	df	Mean Square	F	Sig.
Original data	Regression	1208.528	2	604.264	37.059	.000[b]
	Residual	2282.784	140	16.306		
	Total	3491.312	142			
1	Regression	1122.283	2	561.142	31.517	.000[b]
	Residual	2937.688	165	17.804		
	Total	4059.971	167			
2	Regression	1413.616	2	706.808	38.490	.000[b]
	Residual	3029.948	165	18.363		
	Total	4443.564	167			
3	Regression	1252.226	2	626.113	34.272	.000[b]
	Residual	3014.382	165	18.269		
	Total	4266.608	167			
4	Regression	1261.182	2	630.591	36.478	.000[b]
	Residual	2852.376	165	17.287		
	Total	4113.558	167			
5	Regression	1203.189	2	601.594	33.957	.000[b]
	Residual	2923.175	165	17.716		
	Total	4126.364	167			

Pooled F (2, 383.04) = 31.77, p = .000
a. Dependent Variable: ConceptualPractical
b. Predictors: (Constant), DisabilityLevel, Restoration

Table 28

Environ-Conceptual/Practical Skill Model Coefficients[a]

Imputation Number		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics				
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF[b]	FMI[c]	RIV[d]	RE[e]
Original data	(Constant)	17.459	2.203		7.926	.000					
	Restoration	.397	.072	.379	5.531	.000	.996	1.004			
	DisabilityLevel	-4.234	.677	-.428	-6.252	.000	.996	1.004			
1	(Constant)	16.567	2.069		8.007	.000					
	Restoration	.358	.069	.344	5.191	.000	.999	1.001			
	DisabilityLevel	-3.716	.640	-.385	-5.810	.000	.999	1.001			
2	(Constant)	18.236	2.058		8.863	.000					
	Restoration	.356	.070	.327	5.090	.000	.999	1.001			
	DisabilityLevel	-4.394	.632	-.447	-6.952	.000	.999	1.001			
3	(Constant)	18.548	2.110		8.789	.000					
	Restoration	.334	.069	.317	4.842	.000	.999	1.001			
	DisabilityLevel	-4.340	.663	-.429	-6.546	.000	.999	1.001			
4	(Constant)	17.894	2.064		8.667	.000					
	Restoration	.356	.068	.339	5.226	.000	.998	1.002			
	DisabilityLevel	-4.191	.641	-.424	-6.537	.000	.998	1.002			
5	(Constant)	16.909	2.054		8.231	.000					
	Restoration	.358	.069	.339	5.173	.000	.998	1.002			
	DisabilityLevel	-3.865	.628	-.404	-6.152	.000	.998	1.002			
Pooled	(Constant)	17.631	2.274		7.755	.000			.182	.205	.965
	Restoration	.353	.070		5.036	.000			.027	.027	.995
	DisabilityLevel	-4.101	.719		-5.703	.000			.222	.259	.958

a. Dependent Variable: ConceptualPractical
b. Variance Inflation Factors
c. Fraction Missing Information
d. Relative Increase Variance
e. Relative Efficiency

H1b. Among people with IDD, domains of environmental attributes will positively affect social skills.

Stepwise regression analyses for the Environ-Social Skill model removed the seven variables, including nationality, student age, student gender, duration, affordance, restoration, coherence, and entered two independent variables: control and disability level.

There was a significant relationship between controllable features, disability level, and social skills at the 0.01 level, which accepted Hypothesis 1b ($F(2, 37.77) = 12.068$, $R^2 = 0.181$, $p = .000$) (Table 32, 33). The social skills were predicted by the equation, 8.543 + 0.129(Control) – 1.914 (DisabilityLevel) (Table 34). Controllable features were measured by the sum score of GrossMotor, QuietArea, Multisensory, Auditory, AssistiveTech, SocialArea, Visual items in the Environment Evaluation (EE), and disability level was coded as 1 = mild disability, 2 = moderate disability. This result indicated that the presence of such controllable features in the environment was associated with more frequent occurrence of social skills.

Table 29

Environ-Social Skill Model Summary[ab]

Imputation Number	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
Original data	.425[a]	.181	.168	2.57518	1.805
1	.378[a]	.143	.132	2.79682	1.906
2	.460[a]	.212	.202	2.63264	1.900
3	.433[a]	.187	.178	2.63111	1.975
4	.452[a]	.204	.195	2.63843	1.874
5	.425[a]	.181	.171	2.61213	1.970

Pooled R square = 0.181, adjusted R square = 0.179

a. Predictors: (Constant), DisabilityLevel, Control
b. Dependent Variable: Social

Table 30

Environ-Social Skill Model ANOVA[a]

Imputation Number		Sum of Squares	df	Mean Square	F	Sig.
Original data	Regression	181.770	2	90.885	13.705	.000[b]
	Residual	822.314	124	6.632		
	Total	1004.084	126			
1	Regression	214.606	2	107.303	13.718	.000[b]
	Residual	1290.664	165	7.822		
	Total	1505.270	167			
2	Regression	307.693	2	153.846	22.197	.000[b]
	Residual	1143.583	165	6.931		
	Total	1451.276	167			
3	Regression	263.349	2	131.674	19.021	.000[b]
	Residual	1142.254	165	6.923		
	Total	1405.602	167			
4	Regression	294.941	2	147.470	21.184	.000[b]
	Residual	1148.621	165	6.961		
	Total	1443.562	167			
5	Regression	248.411	2	124.205	18.203	.000[b]
	Residual	1125.831	165	6.823		
	Total	1374.242	167			

Pooled F (2, 37.77) = 12.068, p=.000
a. Dependent Variable: Social
b. Predictors: (Constant), DisabilityLevel, Control

Table 31

Environ-Social Skill Model Coefficients[a]

Imputation Number		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics				
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF[b]	FIM[c]	RIV[d]	RE[e]
Original data	(Constant)	7.667	1.425		5.379	.000					
	Control	.157	.046	.282	3.454	.001	.990	1.010			
	DisabilityLevel	-1.645	.460	-.292	-3.578	.000	.990	1.010			
1	(Constant)	8.498	1.295		6.565	.000					
	Control	.111	.041	.195	2.699	.008	.995	1.005			
	DisabilityLevel	-1.820	.425	-.310	-4.285	.000	.995	1.005			
2	(Constant)	8.616	1.210		7.123	.000					
	Control	.141	.038	.259	3.720	.000	.987	1.014			
	DisabilityLevel	-1.976	.391	-.352	-5.058	.000	.987	1.014			
3	(Constant)	8.577	1.249		6.868	.000					
	Control	.130	.038	.244	3.456	.001	.990	1.010			
	DisabilityLevel	-1.943	.410	-.334	-4.739	.000	.990	1.010			
4	(Constant)	8.908	1.240		7.186	.000					
	Control	.135	.038	.247	3.544	.001	.993	1.007			
	DisabilityLevel	-2.097	.408	-.358	-5.141	.000	.993	1.007			
5	(Constant)	8.117	1.240		6.544	.000					
	Control	.126	.038	.240	3.360	.001	.973	1.028			
	DisabilityLevel	-1.733	.395	-.313	-4.388	.000	.973	1.028			
Pooled	(Constant)	8.543	1.285		6.647	.000			.060	.062	.988
	Control	.129	.040		3.184	.002			.097	.102	.981
	DisabilityLevel	-1.914	.434		-4.406	.000			.134	.146	.974

a. Dependent Variable: Social
b. Variance Inflation Factors
c. Fraction Missing Information
d. Relative Increase Variance
e. Relative Efficiency

H2. Among people with IDD, a set of enabling design features will inversely predict problem behaviors.

As a result of stepwise regression analysis, five control variables were removed, including nationality, disability level, student age, student gender, and duration. Accordingly, one independent variable of environmental attributes was entered in the Environ-Problem Behavior model.

The result of regression analysis was not significant at the 0.05 level, which did not support Hypothesis 2 (H2). There was no significant relationship between environmental attributes and problem behaviors from the pooled dataset ($F(1, 43.42) = 3.244$, $R^2 = 0.034$, $p = .079$) (Table 35, 36). Since the significance level was closer to 0.05, the imputed data were further investigated. The model was significant with the imputed data 1, 3, 4, and 5 ($p = 0.036$, 0,005, 0,009, and 0,003, respectively) (Table 36), suggesting that the environmental attributes ($\beta = -.090$, $-.124$, $-.115$, and $-.123$, respectively) were significant predictors for problem behaviors. This result could indicate environmental attributes inversely predict attentional problem behaviors (Table 37), however, interpretation should be made with caution as there was no significant relationship in the original and pooled dataset.

Furthermore, Pearson correlational coefficient was investigated. A significant, negative correlation was found between environmental attributes and problem behaviors ($R = -.191$, $p = 0.029$) (Table 38).

Table 32

Environ-Problem Behavior Model Summary[ab]

Imputation Number	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
Original data	.135[a]	.018	.006	8.94290	2.024
1	.162[a]	.026	.020	8.55368	1.979
2	.148[a]	.022	.016	8.75125	1.960
3	.217[a]	.047	.041	8.86696	2.070
4	.200[a]	.040	.034	8.74017	1.998
5	.226[a]	.051	.045	8.39653	1.899

Pooled R square = 0.034, adjusted R square = 0.033

a. Predictors: (Constant), EnvironAttributes, b. Dependent Variable: ProblemBehavior

Table 33

Environ-Problem Behavior Model ANOVA[a]

Imputation Number		Sum of Squares	df	Mean Square	F	Sig.
Original data	Regression	122.356	1	122.356	1.530	.220[b]
	Residual	6557.982	82	79.975		
	Total	6680.338	83			
1	Regression	327.222	1	327.222	4.472	.036[b]
	Residual	12145.474	166	73.166		
	Total	12472.695	167			
2	Regression	285.365	1	285.365	3.726	.055[b]
	Residual	12712.996	166	76.584		
	Total	12998.361	167			
3	Regression	642.134	1	642.134	8.167	.005[b]
	Residual	13051.426	166	78.623		
	Total	13693.559	167			
4	Regression	529.884	1	529.884	6.937	.009[b]
	Residual	12680.836	166	76.391		
	Total	13210.720	167			
5	Regression	630.824	1	630.824	8.948	.003[b]
	Residual	11703.274	166	70.502		
	Total	12334.098	167			

Pooled F(1, 43.42) = 3.244, p = .079

a. Dependent Variable: ProblemBehavior, b. Predictors: (Constant), EnvironAttributes

Table 34

Environ-Problem Behavior Model Coefficients[a]

Imputation Number		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics				
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF[b]	FIM[c]	RIV[d]	RE[e]
Original data	(Constant)	23.281	4.796		4.855	.000					
	EnvironAttributes	-.090	.072	-.135	-1.237	.220	1.000	1.000			
1	(Constant)	23.831	2.808		8.486	.000					
	EnvironAttributes	-.090	.043	-.162	-2.115	.036	1.000	1.000			
2	(Constant)	23.518	2.834		8.299	.000					
	EnvironAttributes	-.083	.043	-.148	-1.930	.055	1.000	1.000			
3	(Constant)	25.623	2.850		8.989	.000					
	EnvironAttributes	-.124	.043	-.217	-2.858	.005	1.000	1.000			
4	(Constant)	25.172	2.860		8.801	.000					
	EnvironAttributes	-.115	.044	-.200	-2.634	.009	1.000	1.000			
5	(Constant)	25.929	2.717		9.545	.000					
	EnvironAttributes	-.123	.041	-.226	-2.991	.003	1.000	1.000			
Pooled	(Constant)	24.815	3.053		8.128	.000			.160	.177	.969
	EnvironAttributes	-.107	.048		-2.247	.027			.209	.241	.960

a. Dependent Variable: ProblemBehavior
b. Variance Inflation Factors
c. Fraction Missing Information
d. Relative Increase Variance
e. Relative Efficiency

Table 35

Correlations between Environmental Attributes and Problem Behaviors

Imputation Number			EnvironAttributes	ProblemBehavior
Original data	EnvironAttributes	Pearson Correlation	1	-.135
		Sig. (2-tailed)		.220
		N	135	84
	ProblemBehavior	Pearson Correlation	-.135	1
		Sig. (2-tailed)	.220	
		N	84	95
1	EnvironAttributes	Pearson Correlation	1	-.162*
		Sig. (2-tailed)		.036
		N	168	168
	ProblemBehavior	Pearson Correlation	-.162*	1
		Sig. (2-tailed)	.036	
		N	168	168
2	EnvironAttributes	Pearson Correlation	1	-.148
		Sig. (2-tailed)		.055
		N	168	168
	ProblemBehavior	Pearson Correlation	-.148	1
		Sig. (2-tailed)	.055	
		N	168	168
3	EnvironAttributes	Pearson Correlation	1	-.217**
		Sig. (2-tailed)		.005
		N	168	168
	ProblemBehavior	Pearson Correlation	-.217**	1
		Sig. (2-tailed)	.005	
		N	168	168
4	EnvironAttributes	Pearson Correlation	1	-.200**
		Sig. (2-tailed)		.009
		N	168	168
	ProblemBehavior	Pearson Correlation	-.200**	1
		Sig. (2-tailed)	.009	
		N	168	168

Table 35

Correlations between Environmental Attributes and Problem Behaviors

Imputation Number			EnvironAttributes	ProblemBehavior
5	EnvironAttributes	Pearson Correlation	1	-.226**
		Sig. (2-tailed)		.003
		N	168	168
	ProblemBehavior	Pearson Correlation	-.226**	1
		Sig. (2-tailed)	.003	
		N	168	168
Pooled	EnvironAttributes	Pearson Correlation	1	-.191*
		Sig. (2-tailed)		.029
		N	168	168
	ProblemBehavior	Pearson Correlation	-.191*	1
		Sig. (2-tailed)	.029	
		N	168	168

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

H2a. Among people with IDD, domains of environmental attributes will inversely predict attention problem.

Stepwise regression analyses for the Environ-Attention Problem model removed the six variables, including nationality, student gender, duration, affordance, restoration, and coherence, and entered three independent variables: control, student age, and disability level.

There was a significant relationship between controllable features, student age, disability level, and social skills at the 0.01 level, which accepts Hypothesis 2b ($F (3, 68.15) = 5.195$, $R^2 = 0.110$, $p = .003$) (Table 36, 37). The attentional problem was predicted by the equation, 7.209 + -.093 (Control) + 1.070 (DisabilityLevel) -.370 (StudentAge) (Table 38). Controllable features were measured by the sum score of GrossMotor, QuietArea, Multisensory, Auditory, AssistiveTech, SocialArea, Visual items in the Environment Evaluation (EE). Age was coded as 1 = 14, 2 = 15, 3 = 16, 4 = 17, and 5 = 18. Disability level was coded as 1 = mild disability, 2 =

moderate disability. This result indicated that the presence of such controllable features in the learning environment was associated with fewer occurrence of attentional problem behaviors.

Table 36

Environ-Attention Problem Model Summary[ab]

Imputation Number	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
Original data	.354[a]	.125	.103	2.79002	1.981
1	.294[c]	.087	.070	2.93914	2.125
2	.330[c]	.109	.093	2.83370	2.004
3	.347[a]	.120	.104	2.93555	2.060
4	.376[a]	.141	.125	2.94498	2.198
5	.350[c]	.122	.106	2.83447	2.039

Pooled R square = 0.113, adjusted R square = 0.110
a. Predictors: (Constant), StudentAge, Control, DisabilityLevel
b. Dependent Variable: Attention

Table 37

Environ-Attention Problem Model ANOVA[a]

Imputation Number		Sum of Squares	df	Mean Square	F	Sig.
Original data	Regression	128.291	3	42.764	5.494	.001[b]
	Residual	895.184	115	7.784		
	Total	1023.475	118			
1	Regression	134.221	3	44.740	5.179	.002[c]
	Residual	1416.720	164	8.639		
	Total	1550.942	167			
2	Regression	161.155	3	53.718	6.690	.000[c]
	Residual	1316.897	164	8.030		
	Total	1478.051	167			
3	Regression	192.961	3	64.320	7.464	.000[b]
	Residual	1413.267	164	8.617		
	Total	1606.228	167			
4	Regression	233.788	3	77.929	8.985	.000[b]
	Residual	1422.360	164	8.673		
	Total	1656.148	167			

Table 37 (Continued)

Environ-Attention Problem Model ANOVA[a]

Imputation Number		Sum of Squares	df	Mean Square	F	Sig.
5	Regression	183.518	3	61.173	7.614	.000[c]
	Residual	1317.610	164	8.034		
	Total	1501.127	167			

Pooled F(3, 68.15).= 5.195, p= 0.003

a. Dependent Variable: Attention

b. Predictors: (Constant), StudentAge, Control, DisabilityLevel

Table 38

Environ-Attention Problem Model Coefficients[a]

Imputation Number		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics				
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF[b]	FIM[c]	RIV[d]	RE[e]
Original data	(Constant)	6.979	1.681		4.151	.000					
	Control	-.075	.051	-.129	-1.470	.144	.984	1.016			
	DisabilityLevel	1.153	.517	.196	2.232	.028	.983	1.017			
	StudentAge	-.417	.161	-.228	-2.590	.011	.985	1.015			
1	(Constant)	6.920	1.417		4.884	.000					
	Control	-.093	.043	-.161	-2.142	.034	.988	1.012			
	DisabilityLevel	1.041	.447	.174	2.329	.021	.993	1.008			
	StudentAge	-.243	.130	-.141	-1.874	.063	.990	1.010			
2	(Constant)	7.664	1.347		5.690	.000					
	Control	-.076	.041	-.139	-1.868	.063	.985	1.015			
	DisabilityLevel	.870	.421	.154	2.069	.040	.986	1.014			
	StudentAge	-.439	.132	-.245	-3.316	.001	.998	1.002			
3	(Constant)	7.058	1.473		4.791	.000					
	Control	-.101	.042	-.177	-2.409	.017	.989	1.011			
	DisabilityLevel	1.173	.459	.189	2.558	.011	.984	1.016			
	StudentAge	-.365	.138	-.195	-2.648	.009	.993	1.007			
4	(Constant)	7.395	1.472		5.025	.000					
	Control	-.099	.043	-.170	-2.334	.021	.991	1.010			
	DisabilityLevel	1.140	.457	.182	2.493	.014	.985	1.015			
	StudentAge	-.479	.141	-.247	-3.393	.001	.989	1.011			

Table 38 (Continued)

Environ-Attention Problem Model Coefficients[a]

Imputation Number		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics				
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF[b]	FIM[c]	RIV[d]	RE[e]
5	(Constant)	7.009	1.408		4.977	.000					
	Control	-.096	.041	-.175	-2.350	.020	.968	1.033			
	DisabilityLevel	1.127	.429	.195	2.626	.009	.970	1.031			
	StudentAge	-.325	.132	-.181	-2.467	.015	.991	1.009			
Pooled	(Constant)	7.209	1.464		4.923	.000			.056	.057	.989
	Control	-.093	.043		-2.149	.032			.066	.068	.987
	DisabilityLevel	1.070	.463		2.314	.021			.087	.091	.983
	StudentAge	-.370	.169		-2.191	.036			.403	.574	.925

a. Dependent Variable: Attention
b. Variance Inflation Factors
c. Fraction Missing Information
d. Relative Increase Variance
e. Relative Efficiency

H2b. Among people with IDD, domains of environmental attributes will inversely predict internalizing problem.

The hypothesis 2b was not supported by the collected sample.

H2c. Among people with IDD, domains of environmental attributes will inversely predict externalizing problem.

The hypothesis 2c was not explained by the collected sample.

Result Summary

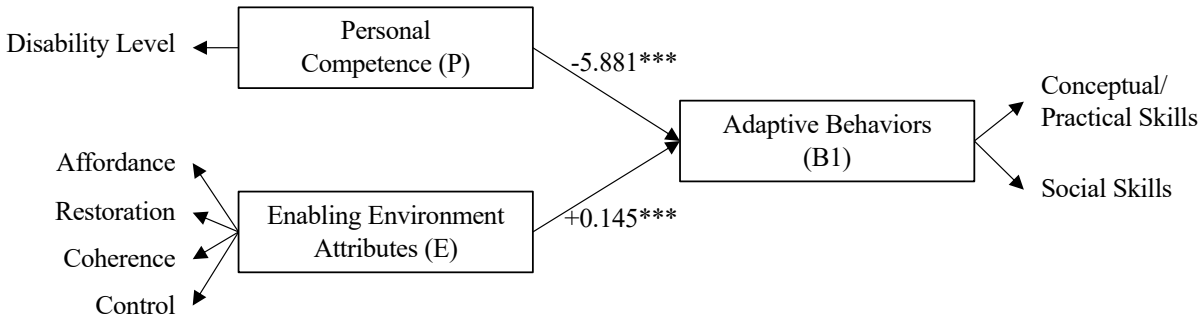
Factor analyses inspected the dimensionality of the two measures modified for this study's use, including the Environmental Evaluation (EE) and the Performance Measure (PM). As the hypothesized subscales were not supported by the collected dataset, subscales were redefined. As a result, the EE was defined by four subscales: affordance, restoration, control, and coherence. When it comes to the PM, two components were suggested: conceptual/practical, and social skills.

Multiple imputation regression confirmed four hypotheses (Figure 7, 8, 9, and 11). Results of multiple regression analyses supported that a set of DG-IDD is positively associated with adaptive behaviors when students' disability level was controlled (the Environ-Adaptive Behavior model; $F (2, 90.13) = 25.363$, $R^2 = 0.278$, $p = .000$) (Figure 7). Specifically, restorative features were associated with conceptual/practical skills ($F (2, 383.04) = 31.77$, $R^2 = 0.301$, $p = .000$) (Figure 8), and the controllable characteristics were relevant to social skills ($F (2, 37.77) = 12.068$, $R^2 = 0.181$, $p = .000$) (Figure 9). Meanwhile, regression analysis with the collected data did not support the Environ-Problem Behavior Model. The collected data also did not support any relationships between the design features and internalizing or externalizing problem behaviors. However, correlation analysis displayed the negative relationship between the DG-

IDD problem behaviors (R = -0.191, p = 0.05) (Figure 10). Furthermore, controllable features negatively predict attentional problem behaviors controlling student age and disability levels (F (3, 68.15) = 5.195, R^2 = 0.110, p =.003) (Figure 11).

Figure 7

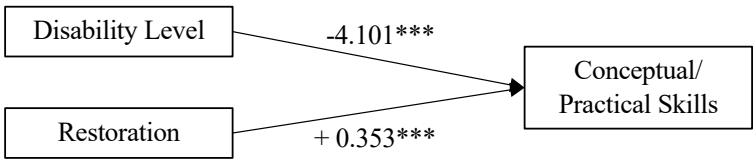
Environ-Adaptive Behavior Model (H1)



Note. Pooled R square = 0.278, adjusted R square = 0.276, pooled F (2, 90.13) = 25.363, p = .000, power = .979 at effect size of 0.15 and alpha of 0.01

Figure 8

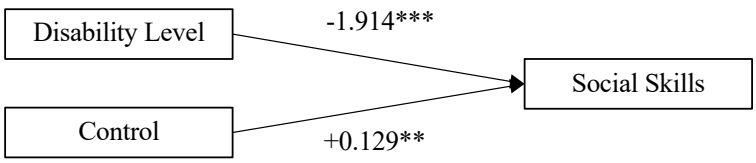
Environ-Conceptual/Practical Skill Model (H1a)



Note. Pooled R square = 0.301, adjusted R square = 0.300, pooled F (2, 383.04) = 31.77, p = .000, power = .979 at effect size of 0.15 and alpha of 0.01

Figure 9

Environ-Social Skill Model (H1b)



Note. Pooled R square = 0.181, adjusted R square = 0.179, pooled F (2, 383.04) = 12.068, p = .000, power = .979 at effect size of 0.15 and alpha of 0.01

Figure 10

Environ-Problem Behavior Correlations

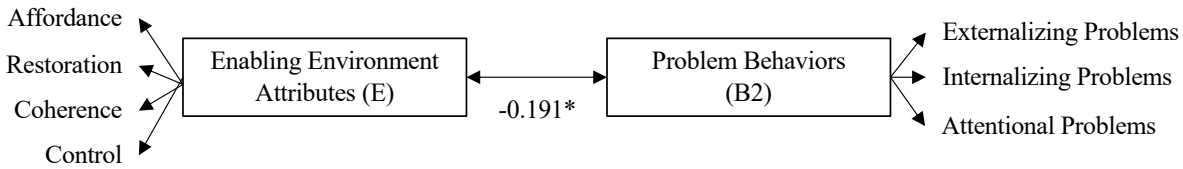
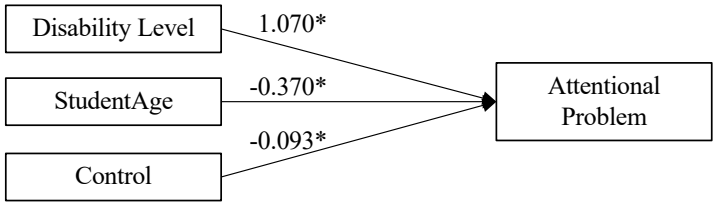


Figure 11

Environ-Attention Problem Model (H2a)



Note. Pooled R square = 0.113, adjusted R square = 0.110, pooled F (3, 68.15) = 5.195, p = .003, power = .964 at effect size of 0.15 and alpha of 0.01

Discussion

Recommendations

This study provides a set of evidence-based design guidelines for people with intellectual and developmental disabilities (DG-IDD) (Table 39). The learning environments which have all environmental attributes listed in DG-IDD are expected to positively predict students' adaptive behaviors while inversely predict their problem behaviors.

Validity and Reliability of DG-IDD

Validity is affected by the types of research design. This research employed observational relationship-based research design, well-structured study design using established standards and methods. The constructs were precisely defined and illustrated based on existing theories. For content validity of the modified measures, the operational definitions (survey items) of this study's constructs were reviewed by eight experts in environmental design or special education. To ensure its construct validity, factor analyses were conducted. The results of exploratory factor analysis for the Environmental Evaluation (EE) and Performance Measure (PM) respectively indicated 51% and 59% of total variance explained, which are at acceptable levels.

For the modified EE and PM, Cronbach's Alpha was further computed to measure internal consistency. The result demonstrated high reliability for EE (alpha = 0.90) and PM (alpha = .94). When it comes to the use of the existing measure, the BPM showed high test-retest reliability for total score (Pearson r = 0.93), as well as subscale scores, internalizing (r = 0.86), externalizing (0.88), and attentional problems (r = 0.93) (Achenbach et al., 2011). The internal consistencies of the BPM were 0.90, 0.80, 0.88, and 0.87 for total, internalizing, externalizing, and attentional problem scores, respectively (Achenbach et al., 2011).

Table 39

Design Guideline for People with Intellectual and Developmental Disabilities (DG-IDD)

	Adaptive Behaviors		Problem Behaviors
	Conceptual/ Practical	Social	Attention
Component 1: Affordance			
The design assists users to adequately use a space or object according to its function.			
1.1. Text: Text is written at a lower secondary education level with a recognizable font (sanserif font), size and spacing.			
1.2. Highlight: Important signage/labels information is highlighted (e.g. bold text, illumination, perpendicular installation, etc.)			
1.3. Non-text: Non-text components are used in environmental cues (e.g. concrete figures, numbers, symbols, colors, etc.)			
1.4. Symbols: Signage/labels with symbols (e.g. arrows) are designed and placed in a way that enables a direct, clear interpretation for the student.			
1.5. Contrast: Color contrast is apparent between background and content, or between colors in the content.			
1.6. Repetition: There are navigational aids present for the student in a cohesive way (e.g. consistent color coding, graphics, etc.).			
1.7. Environmental Cue: The environmental cues – e.g. signage, landmarks, visual instructions, etc. – are appropriately located at decision-making points, where the activities are to be performed.			
Component 2: Restoration			
The environment supports users to cope with stress and address behavior problems when they are externalized.			
2.1. Natural Light: The student is provided the opportunity to natural light.	+		
2.2. Low Arousal (Tactile): Indoor temperature is consistently controlled.	+		
2.3. Natural Scene: The student is provided the opportunity to natural scenes.	+		
2.4. Low Arousal (Olfactory): Indoor air quality is consistently controlled.	+		
2.5. Naturalness: Natural features are found inside of the building (e.g. materials, artwork, plants, etc.).	+		
2.6. Personal Space: Expanded personal space is allowed for the student (e.g. wide hallways, workstations, etc.).	+		

Table 39 (Continued)

Design Guideline for People with Intellectual and Developmental Disabilities (DG-IDD)

	Adaptive Behaviors		Problem Behaviors
	Conceptual/ Practical	Social	Attention
Component 3: Control			
The environment enables users to choose or regulate their social interaction by their needs.			
3.1. Gross-motor Area: Gross motor skill areas are provided with easy access for the student (e.g. large open space with high ceilings, slide, swing, climbing, etc.).		+	+
3.2. Quiet Area: Quiet rooms (or areas) are located separately from the primary social areas while remaining in the proximate distance.		+	+
3.3. Multisensory: Multiple physical setting options are provided for variation in sensory condition and easy access (e.g. sensory rooms; high vs. low stimulus zones; containment vs. openness; with vs. without background sound; etc.).		+	+
3.4. Low Arousal (Auditory): Noise is controlled by the remote placement of noise sensitive spaces from spaces known to be noise producing.		+	+
3.5. Assistive Tech: Assistive technology is used to control the environment (e.g. electrical appliances controller, blind controls devises, virtual assistant, etc.).		+	+
3.6. Social Area: Social areas are provided with easy access for the student (e.g. general purpose, dining areas, niche/alcove within corridor, etc.).		+	+
Component 4: Coherence			
The design helps users reduce cognitive overload and organize the context of environments.			
4.1. Building Shape: The building's shape is simple (e.g. the minimized number of floors, corners, intersections, and length of hallways).			
4.2. Visual Access: Clear visual access for the student is provided (e.g. use of half-walls, preview windows, open shelves/floorplans, etc.)			
4.3. Compartmentalization: Each room (or area) has a single function and is defined with a clear boundary.			
4.4. Transition: Distinctive sensory zones – e.g. high or low stimulus - are connected with transition areas to recalibrate students' senses.			
4.5. Routine: Spaces are sequenced by logical order (e.g. a sequence of activities, routines, sensory characteristics, etc.).			
4.6. Efficient Circulation: The students' major routes are direct and short (e.g. from entrance to a classroom, a classroom to restrooms, external play areas, etc.).			

Note. '+' indicates environmental attributes associated with specific behavioral outcomes.

Contributions

The primary audiences of this study will be researchers who investigate human-environment interactions. The DG-IDD provides a set of references for each design strategy. In this way to connect researchers to the previous studies, researchers can have a sense of which areas have been addressed and where additional research is needed to increase the validity and reliability of the previous findings. This research will be a groundwork to inform a wide range of issues in creating and evaluating learning environments. It will also be a foundation to frame future environmental intervention research.

Another contribution of this research will be as a connector between theoretical research and educational or architectural practices. There has been a growing trend toward evidence-based practice (EBP) and evidence-based design (EBD). However, there have been limitations in engaging practitioners and designers in EBP and EBD. The DG-IDD that will be disseminated as a form of a website that will be easily accessed by practitioners. The website will play a role as a facilitator to fill the gap between research and practices.

The secondary audiences are designers, policymakers, and service providers, who are dedicated to creating learning environments for people with IDD. The DG-IDD will help the practitioners to make more effective design decisions. Evidence level is important in minimizing expected errors and repeating mistakes in architectural practices as well as in planning and implementing policies. Architects, policymakers, and service providers have heavily relied on experts' opinions without reliable empirical studies. The presented research has collected design considerations from the previous studies, including not only strong evidence but also evidence at relatively lower levels, to statistically test and enhance the quality of evidence. The tested

guidelines will reduce the negative impacts of opinion-driven design and provide practitioners guidance with an improved evidence level.

Ultimately, by creating optimal environments for people with IDD, this research will contribute to addressing their behaviors, learning outcomes, and independence. Furthermore, the inclusive impact of this research will not be limited to the population with IDD. It will also have impacts on the quality of life and independence for children whose spatial cognitive ability is developing and elderly people whose cognitive functioning is declining.

Limitations and Future Study

Limitations existed in the systematic review process. The systematic review method has not been established in environment and behavior studies. This study referred to the systematic review guidelines provided by the relatively well-established sector, evidence-based medicine field. Reflecting different aspects of the two study fields, the environment and behavior study field needs to establish an appropriate systematic review procedure to promote evidence-based design. Furthermore, one researcher completed the review process. According to Thomas et al.'s (2004) recommendation, two or more researchers need to independently assess the quality of the selected articles, and differences should be resolved through discussion and an informal consensus process.

Limitations also existed in the recruitment method. Considering cultural differences, this study implemented different recruitment strategies for South Korea and the United States. For example, different incentives were applied. Every person who completed the survey received around $3 in South Korea, while respondents were entered to win one of thirty $10 gift cards in the United States. Such distinctive recruitment methods resulted in different response rates. It is recommended to find a culturally appropriate way to boost the response rate. It was also found

that recruiting respondents from the researcher's direct network was more effective than recruiting from the researcher's secondary network.

Accordingly, there was a limitation in the collected sample. There existed a possibility that the sample used for the analyses was biased. The collected sample more represents South Korea than the United States. To address it, the nationality factor was entered in the regression as one of the control variables and did not show significant p value. This result indicated there was no significant difference between the two countries. In a separate analysis in which regression models were run only with the South Korea sample and then with the combined sample, it was confirmed that adding a U.S. sample enhanced the findings in the South Korea sample. Therefore, this study concluded there is no significant cultural difference between the two nations. Future cross cultural studies might validate this finding by comparing the results from the two countries' separate samples.

There was a high missing data rate among the Brief Problem Monitor (BPM). The majority of items which missing data rate were higher than 15% consisted of items measuring internal and external problems. The respondents may be difficult to answer their care-receiver's internal status (e.g. feels guilty, worries, self-consciousness, worthless, and unhappy) or may uncomfortable to report their care-receiver's external problems (e.g. threatens people, temper, argues, destroy things, and stereotyped behaviors). Another possible reason for the high missing data rate could be the sequence of the survey. The BPM items have been listed on the last page of the survey. The number of survey questions and administration time might cause the higher missing data rate. Or, the BPM items might not be fully addressed by caregivers' observations. The copyright holder of the BPM provides a set of questionnaires designed to be directly reported by students with intellectual and developmental disabilities (IDD), called Brief Problem

Monitor Youth Form (BPM-Y). The implementation of the BPM-Y and qualitative interview with students with IDD will help to fully elaborate the current findings.

The presented study provided a set of design guidelines for people with intellectual and developmental disabilities (DG-IDD). Future studies could further investigate each guideline in detail. Also, the finding's evidence level will be strengthened by experimental, intervention studies. Such accumulated efforts will produce evidence-based knowledge in creating inclusive environments for people with IDD.

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Appendix A. Copies of Permission

Monday, May 10, 2021 at 14:00:51 Central Daylight Time

Subject: Re: Full Paper Copyright Question
Date: Tuesday, April 13, 2021 at 8:55:04 AM Central Daylight Time
From: Libby B. Blume
To: Yi, Yeji
CC: Claudia Bernasconi

Hi Yeji,
Yes, just cite your paper in the *Proceedings of the 52nd Environmental Design Research Association Conference* (2021) as you would any other reference.
Best regards, Dr. Blume

Libby Balter Blume, Ph.D, CFLE

Professor Emerita, Psychology and Architecture
Fellow, National Council on Family Relations
University of Detroit Mercy

Former Editor, *Journal of Family Theory & Review*
Co-Editor, *Teaching and Designing in Detroit*
Co-Chair, *EDRA52 Detroit: Just Environments*

4001 W. McNichols
Detroit, MI 48221-3038
313-578-0446
blumelb@udmercy.edu
Pronouns: she/her/hers

On Apr 13, 2021, at 9:45 AM, EDRA Conference <conference@edra.org> wrote:

Yeji,

I believe it is appropriate to do so, but I am forwarding this request to Dr. Blume who is part of the Conference Review Committee for confirmation. She will be able to give you more guidance.

Best
Claudia

On Tue, Apr 13, 2021 at 9:33 AM Yi, Yeji <yeji.yi@ou.edu> wrote:

> EDRA team,
>
> I have a question about the full paper copyright (**EDRA 52 # 9954: Accessible Environment for People with Cognitive Disabilities: Toward an Integrative Theoretical Framework and Future Research**).
>
> This paper was not published or presented elsewhere before, but I would like to use some part of the paper for my doctoral dissertation which will be published in May.
>
> Could I ask permission to use the part of the paper for my dissertation?

Best regards,
Yeji Yi

--
Claudia

EDRA52 Conference Chair
EDRA Program Committee Chair

Claudia Bernasconi
Associate Professor
Director, Master of Architecture Program
School of Architecture
University of Detroit Mercy

Environmental Design Research Association (EDRA)
EDRA 52 Conference Committee

Subject: RE: EDRA 52 Paper Permission Request
Date: Monday, May 10, 2021 at 3:54:00 PM Central Daylight Time
From: Ellis, Natalie D.
To: Yi, Yeji

I agree!!!!!!!!!!

Natalie Ellis, PhD, IIDA, LEED BD+C

-----Original Message-----
From: Yi, Yeji
Sent: Monday, May 10, 2021 1:56 PM
To: Ellis, Natalie D. <nellis@ou.edu>
Subject: EDRA 52 Paper Permission Request

Dr. Natalie Ellis,

I am writing to ask your permission as a co-author to use the paper titled “Accessible Environment for People with Cognitive Challenges: Toward an Integrative Theoretical Framework and Future Research” in my dissertation. If you permit the use, please reply to this message indicating your agreement. Thank you so much!

Best regards,
Yeji Yi

Appendix B. Survey

Consent to Participate in Research at the University of Oklahoma
[OU-NC IRB Number: 12412 Approval Date: 12/23/2020]

You are invited to participate in our research study entitled "The environmental design factors associated with functional independence for people with intellectual and developmental disabilities". You were selected as a possible participant because you are either a caregiver, a teacher, or a care provider for someone who is between the ages of 14 and 18 with mild or moderate intellectual and developmental disabilities.

To qualify for the survey participation, you should be at least 18 years of age.

If you qualify and agree to participate, you will be directed to complete the online survey. You will be asked to answer questions about your student, child, or person in your care's performance and/or their learning environment. Your participation will take approximately 10 minutes.

Your participation is voluntary and your responses will be anonymous.

There are no foreseeable risks involved in participating in this study.

The gathered data will be used to develop an environmental fit design guidelines for people with intellectual and developmental disabilities. After removing all identifiers, we may share your data with other researchers or use the data in future research without obtaining additional consent from you.

Data will be collected through an online survey system, known as Qualtrics. Qualtrics has its own privacy and security policies further ensuring enhanced confidential information storage.

Even if you choose to participate now, you may stop participating at any time and for any reason. If you have questions about this research, please contact: Yeji Yi yeji.yi@ou.edu /(405) 679-8247, or Dr. Natalie Ellis nellis@ou.edu. Additionally, you can contact the University of Oklahoma – Norman Campus Institutional Review Board at 405-325-8110 or irb@ou.edu with any questions, concerns or complaints regarding your rights as a research participant.

Please print this document for your records. Please select your choice below. Clicking on the "I agree to participate" indicates your agreement to the above information provided by the researcher(s) and your willingness to participate.

- o I agree to participate
- o I do not want to participate

[Demographic Information]
Select the response that best describes you.

Your relation to students with intellectual and developmental disabilities

- Classroom Teacher
- Counselor
- Special Educator
- Administrator
- Parents
- Grandparents
- Other (If you selected other, please specify: _____)

*If a participant chose classroom teacher, counselor, special educator, administrator, or others, the Teacher Survey was displayed online.

**If a participant chose parents or grandparents, the Parent Survey was shown online.

TEACHER SURVEY

How long have you worked with the student with intellectual developmental disabilities?

- Less than 1 year
- 1 year to less than 5 years
- 5 years to less than 10 years
- 10 years to less than 15 years
- 15 years and more

Your gender

- Male
- Female
- Non-binary/third gender
- Prefer not to say

[Child Demographic Information]
Select the response(s) best describe(s) your student's characteristics. This survey measures an individual with intellectual and developmental disabilities. If you have worked with more than one student, choose one student, and answer the questions.

Your student's age

- 14
- 15
- 16
- 17
- 18

Your student's gender
- Male
- Female
- Non-binary/third gender
- Prefer not to say

Your student's disability types (Select all that apply)
- Intellectual Disability
- Autism Spectrum Disorders (ASD)
- Other (If you selected other, please specify: _____)

Your student's disability level
- Mild Intellectual Disability (Approximate IQ range 50 – 69)
- Moderate Intellectual Disability (Approximate IQ range 35 – 49)

Your student's educational setting in which you are interacting with them.
- Home
- Separate Special Education School
- Separate Special Education Class
- Inside Regular Class
- Separate Day Facility
- Homebound/Hospital
- Residential Facility
- Correctional facility
- Service Provider Location

How long has your student been engaged in the learning environment that you defined in the previous question?
- Less than 1 year
- 1 year to less than 2 years
- 2 years to less than 3 years
- 3 years to less than 4 years
- 4 years and more

[Environmental Evaluation]
Choose the single response that best describes your student's learning environment in which you are interacting with them.
0 – Never 1- Rarely 2- Sometimes 3- Often 4- Always

	0	1	2	3	4
Spaces are sequenced by logical order (e.g. a sequence of activities, routines, sensory characteristics, etc.)					
The students' major routes are direct and short (e.g. from entrance to a classroom, a classroom to restrooms, external play areas, etc.).					
Each room (or area) has a single function and is defined with a clear boundary.					
Distinctive sensory zones – e.g. high or low stimulus - are connected with transition areas to recalibrate students' senses.					
Clear visual access for the student is provided (e.g. use of half-walls, preview windows, open shelves/floorplan, etc.).					
The building's shape that the classroom space is located is simple (e.g. the minimized number of floors, corners, intersections, and length of hallways).					
The environmental cues – e.g. signage, landmarks, visual instructions, etc. – are appropriately located at decision-making points, where the activities are to be performed.					
There are navigational aids present for the student in a cohesive way (e.g. consistent color coding, graphics, etc.).					
Non-text components are used in environmental cues (e.g. concrete figures, numbers, symbols, colors, etc.).					
Text is written at lower secondary education level with recognizable font (sanserif font), size, and spacing.					
Color contrast is apparent between background and content, or between colors in the content.					
Signage/labels with symbols (e.g. arrows) are designed and placed in a way that enables a direct, clear interpretation for the student.					

Important signage/labels information is highlighted (e.g. bold text, illumination, perpendicular installation, etc.).					
Multiple physical setting options are provided for variation in sensory condition and easy access (e.g. sensory rooms; high vs. low stimulus zones; containment vs. openness; with vs. without background sound; etc.).					
Quiet rooms (or areas) are located separately from the primary social areas while remaining in the proximate distance.					
Social areas are provided with easy access for the student (e.g. general purpose, dining areas, niche/alcove within corridor, etc.).					
Gross motor skill areas are provided with easy access for the student (e.g. large open space with high ceilings, slide, swing, climbing, etc.).					
The student is provided the opportunity to natural light.					
The student is provided the opportunity to natural scenes.					
Natural features are found inside of the building (e.g. plants, artwork, materials, etc.).					
Expanded personal space is allowed for the student (e.g. wide hallways, workstations, etc.).					
Indoor temperature is consistently controlled.					
Indoor air quality is consistently controlled.					
There is no visual clutter. (e.g. excessive color, pattern, or flickering lighting.					
Noise is controlled by the remote placement of noise sensitive spaces from spaces known to be noise producing.					
Assistive technology is used to control environment (e.g. electrical appliances controller, blind controls devises, virtual assistant, etc.).					

[Performance Measure]
Answer each question below that considers your student's primary learning environment and performance **now or within the past 30 days**. The questions are intended to measure what a person with intellectual and developmental disabilities ACTUALLY DOES, not what should or might be able to do. Choose the number that best represents how frequently your student performs each activity independently in his/her learning environment.
0 – Never: rarely or never does it
1 – Sometimes: sometimes does it independently, but sometimes needs assistance
2 – Always: does it always or almost always independently

	0	1	2
Can navigate through the spaces to get to their desired destination (e.g. travel to restrooms, classroom transition, etc.)			
Can make decisions and solve problems when disoriented in the learning environment			
Can recognize spaces according to their purpose and activity (e.g. study, leisure, dining areas, etc.)			
Can recognize intended equipment, supplies, or furniture purpose			
Can perform different types of learning activities independently (e.g. academic, vocational, group learning, etc.)			
Can follow daily scheduled activities independently (e.g. daily tasks, eating, cleaning up, etc.)			
Can interpret the meaning of the environment's visual cue provision (e.g. restrooms, labels, visual instructions, etc)			
Can read and understand information on visual instruction/signage			
Can take care of personal needs (e.g. toileting, hygiene, etc.)			
Can use personal storage properly			
Can respect one's own and others' personal spaces while engaged with others			
Can use designated spaces intended for the purpose of withdrawal in order to cope with emotional behaviors in social situation			
Can follow classroom rules			
Can initiate and engage in different types of play (e.g. solitary, parallel, group play, etc.)			
Can participate in social or recreational activities			

[Brief Problem Monitor]

Please rate each item to describe your student now or within the past 30 days. Please answer all items as well as you can, even if some do not seem to apply to your student. (Reproduced Under License # 2215-01-04-21)

0 – Not true (as far as you know)
1 – Somewhat true
2 – Very true

	0	1	2
Acts too young for his/her age			
Argues a lot			
Fails to finish things they start			
Can't concentrate, can't pay attention for long periods of time			
Can't sit still, restless, or hyperactive			
Destroys things belonging to others			
Disobedient at school			
Feels worthless or inferior			
Impulsive or acts without thinking			
Too fearful or anxious			
Feels too guilty			
Self-conscious or easily embarrassed			
Inattentive or easily distracted			
Stubborn, sullen, or irritable			
Temper tantrums or hot temper			
Threatens people			
Unhappy, sad, or depressed			
Worries			
Stereotyped/repetitive/self-stimulatory behaviors			

[Future Study]
If you are willing to be further participate beyond this study, please provide your name and preferred form of contact (email, phone, etc.). You will be asked to complete this survey again to assess test-retest reliability. You can skip this request if desired. We appreciate your participation.

_____

PARENT SURVEY

[Demographic Information]
Select the response that best describes you.

Your gender
- o Male
- o Female
- o Non-binary/third gender
- o Prefer not to say

[Child Demographic Information]
Select the response(s) best describe(s) your child's characteristics. This survey is seeking to identify information for an individual with intellectual and developmental disabilities. If you have worked with more than one child, choose one child, and answer the questions accordingly.

Your child's age
- o 14
- o 15
- o 16
- o 17
- o 18

Your child's gender
- o Male
- o Female
- o Non-binary/third gender
- o Prefer not to say

Your child's disability types (Select all that apply)
- ▪ Intellectual Disability
- ▪ Autism Spectrum Disorders (ASD)
- ▪ Others (If you selected others, please specify: _____)

Your child's disability level
- o Mild Intellectual Disability (Approximate IQ range 50 – 69)
- o Moderate Intellectual Disability (Approximate IQ range 35 – 49)

Your child's educational setting in which you are interacting with them.

- Home
- Separate Special Education School
- Separate Special Education Class
- Inside Regular Class
- Separate Day Facility
- Homebound/Hospital
- Residential Facility
- Correctional facility
- Service Provider Location

How long has your child been engaged in the learning environment that you defined in the previous question?

- Less than 1 year
- 1 year to less than 2 years
- 2 years to less than 3 years
- 3 years to less than 4 years
- 4 years and more

[Environmental Evaluation]

Choose the single response that best describes your child's learning environment in which you are interacting with them.

0 – Never 1- Rarely 2- Sometimes 3- Often 4- Always

	0	1	2	3	4
Spaces are sequenced by logical order (e.g. a sequence of activities, routines, sensory characteristics, etc.)					
The child's major routes are direct and short (e.g. from entrance to a classroom, a classroom to restrooms, external play areas, etc.).					
Each room (or area) has a single function and is defined with a clear boundary.					
Distinctive sensory zones – e.g. high or low stimulus - are connected with transition areas to recalibrate children's senses.					
Clear visual access for the child is provided (e.g. use of half-walls, preview windows, open shelves/floorplan, etc.).					
The building's shape that the study room is located is simple (e.g. the minimized number of floors, corners, intersections, and length of hallways).					
The environmental cues – e.g. labels, visual instructions, etc. – are appropriately located at decision-making points, where the activities are to be performed.					
There are navigational aids present for the child in a cohesive way (e.g. consistent color coding, graphics, etc.).					
Non-text components are used in environmental cues (e.g. concrete figures, numbers, symbols, colors, etc.).					
Text is written at lower secondary education level with recognizable font (sanserif font), size, and spacing.					
Color contrast is apparent between background and content, or between colors in the content.					
Signage/labels with symbols (e.g. arrows) are designed and placed in a way that enables a direct, clear interpretation for the child.					

Important signage/labels information is highlighted (e.g. bold text, illumination, perpendicular installation, etc.).					
Multiple physical setting options are provided for variation in sensory condition and easy access (e.g. sensory rooms; high vs. low stimulus zones; containment vs. openness; with vs. without background sound; etc.).					
Quiet rooms (or areas) are located separately from the primary social areas while remaining in the proximate distance.					
Social areas are provided with easy access for the child (e.g. general purpose, dining areas, etc.).					
Gross motor skill areas are provided with easy access for the child (e.g. large open space with high ceilings, slide, swing, climbing, etc.).					
The child is provided the opportunity to natural light.					
The child is provided the opportunity to natural scenes.					
Natural features are found inside of the building (e.g. plants, artwork, materials, etc.).					
Expanded personal space is allowed for the child (e.g. wide workstations, etc.).					
Indoor temperature is consistently controlled.					
Indoor air quality is consistently controlled.					
There is no visual clutter (e.g. excessive color, pattern, or flickering lighting).					
Noise is controlled by the remote placement of noise sensitive spaces from spaces known to be noise producing.					
Assistive technology is used to control environment (e.g. electrical appliances controller, blind controls devises, virtual assistant, etc.).					

[Performance Measure]
Answer each question below that considers your student's primary learning environment and

performance **now or within the past 30 days**. The questions are intended to measure what a person with intellectual and developmental disabilities ACTUALLY DOES, not what should or might be able to do. Choose the number that best represents how frequently your child performs each activity independently in his/her learning environment.
0 – Never: rarely or never does it
1 – Sometimes: Sometimes does it independently, but sometimes needs assistance
2 – Always: does it always or almost always independently

	0	1	2
Can navigate through the spaces to get to their desired destination (e.g. travel to restrooms, dining area, etc.)			
Can make decisions and solve problems when disoriented in the learning environment			
Can recognize spaces according to their purpose and activity (e.g. study, leisure, dining areas, etc.)			
Can recognize intended equipment, supplies, or furniture purpose			
Can perform different types of learning activities independently (e.g. academic, vocational, group learning, etc.)			
Can follow daily scheduled activities independently (e.g. daily tasks, eating, cleaning up, etc.)			
Can interpret the meaning of the environment's visual cue provision (e.g. restrooms, labels, visual instructions, etc)			
Can read and understand information on visual instruction/signage			
Can take care of personal needs (e.g. toileting, hygiene, etc.)			
Can use personal storage properly			
Can respect one's own and others' personal spaces while engaged with others			
Can use designated spaces intended for the purpose of withdrawal in order to cope with emotional behaviors in social situation			
Can follow house rules			
Can initiate and engage in different types of play (e.g. solitary, parallel, group play, etc.)			
Can participate in social or recreational activities			

[Brief Problem Monitor]
Please rate each item to describe your child now or within the past 30 days. Please answer all items as well as you can, even if some do not seem to apply to your child. (Reproduced Under License # 2215-01-04-21)

0 – Not true (as far as you know)
1 – Somewhat true
2 – Very true

	0	1	2
Acts too young for his/her age			
Argues a lot			
Fails to finish things they start			
Can't concentrate, can't pay attention for long periods of time			
Can't sit still, restless, or hyperactive			
Destroys things belonging to his/her family or others			
Disobedient at home			
Disobedient at school			
Feels worthless or inferior			
Impulsive or acts without thinking			
Too fearful or anxious			
Feels too guilty			
Self-conscious or easily embarrassed			
Inattentive or easily distracted			
Stubborn, sullen, or irritable			
Temper tantrums or hot temper			
Threatens people			
Unhappy, sad, or depressed			
Worries			
Stereotyped/repetitive/self-stimulatory behaviors			

[Future Study]
If you are willing to be further participate beyond this study, please provide your name and preferred form of contact (email, phone, etc.), and check which study you want to participate in. You can skip this request if desired. We appreciate your participation.

_____

I want to participate in

- Test-retest: you will be asked to complete this survey again.
- Child Interview: you and your child will be asked to participate in a 15-minute interview, and your child will answer 10 questions about how they feel in their learning environment.

Appendix C. Interview Protocol

Introduction

Thank you for your time and willingness to participate. As you are informed, I am interested in making a better environment for students like you. In this interview, I would like to learn from you about how you feel in your [school/home/center/others] when doing certain activities. I will ask twelve questions. You can decline or pass on any of the questions. Do you have any questions before we start?

Interview Questions

[Adaptive Behaviors]

1. How easy is it to navigate and find a way to where you want to go in your [school/home/center/others]? Choose an answer among easy, moderate, or hard.
   Probe: What [helps/bothers] you to navigate and find a way?

2. How easy is it to complete daily activities in your [school/home/center/others]? Choose an answer among easy, moderate, or hard.
   Probe: What [helps/bothers] you to complete daily activities?

3. How easy is it to interact with others in your [school/home/center/others]? There are three options to answer: easy, moderate, or hard.
   Probe: What [helps/bothers] you to interact with others?

[Problem Behaviors]

4. How easy is it to concentrate on your tasks in your [school/home/center/others]? Choose an answer among easy, moderate, or hard.
   Probe: What [helps/bothers] you to concentrate on your task?

5. How easy is it to be comfortable in your [school/home/center/others]? Choose an answer among easy, moderate, or hard.
   Probe: What [helps/bothers] you to be comfortable?

6. When you have a bad feeling in your [school/home/center/others], how easy is it to be away from that feeling? Choose an answer among easy, moderate, or hard.
   Probe: What [helps/bothers] you to away from the negative feeling?

Closing

Now we are done. Do you have any questions about this research project? If you want to contact me later, you can contact me via email or with help with your parents. Also, I may need to contact you later for additional questions or clarification. I appreciate your time and answers.

Appendix D. Recruitment Material

Our research study seeks to
create design guidelines that will aid the cognitive function of people with intellectual and developmental disabilities.

You are being asked to complete the following:
- a 10-minute online survey
- a 15-minute child interview (optional and after the initial 10-minute survey)
- a 10-minute reliability test (optional)

You may be eligible if you are
- a caregiver
- a teacher
- a service provider

And if you have experience working with
- children with mild/moderate intellectual disabilities or autism spectrum disorders
- in the age range of 14 - 18
- who were qualified to receive special education

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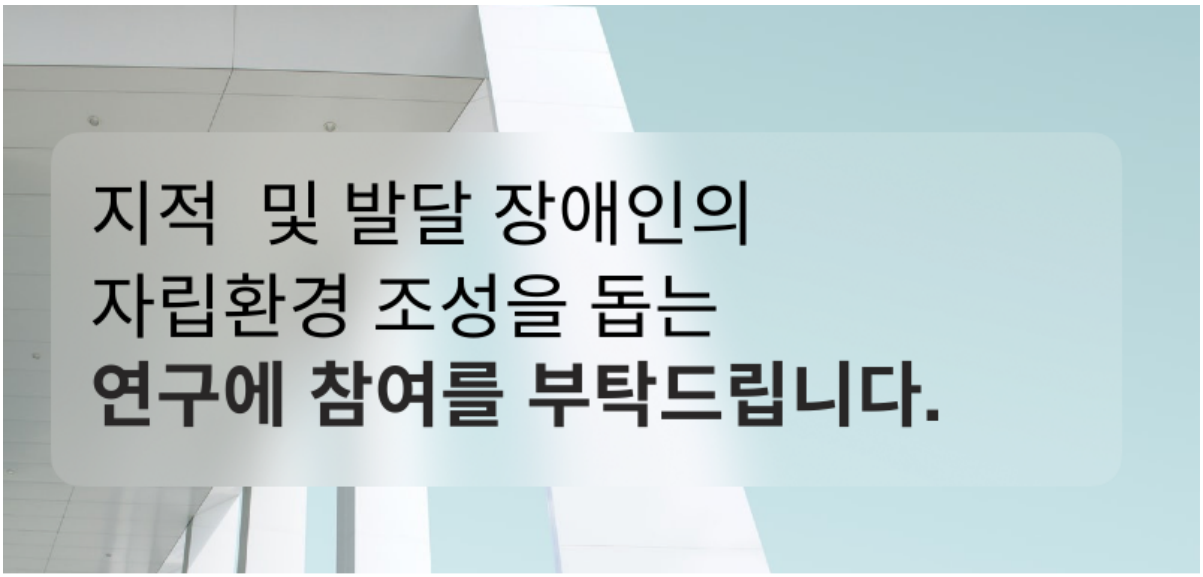

연구 목적
본 연구에서는 지적 및 발달장애인의 독립 생활을 지원하는 디자인 가이드라인을 개발하고자 합니다.

참여 활동
본 연구를 위해 온라인 설문에 참여를 부탁드립니다 (10분 소요 예상). 모든 설문 문항에 응답하신 분들에게 3,000원 상품권을 지급합니다.

참여 가능 조건
(1) 만 14 - 18세 (2) 특수교육 대상인 (3) 경도/중증도 (4) 지적장애인/자폐 스펙트럼장애인과 생활한 경험이 있는 보호자, 특수교육 관련 교사, 장애 관련 시설 종사자라면 설문에 참여할 수 있습니다.

본 연구에 대한 정보 혹은 참여를 원하신다면 다음 주소를 방문해 주십시오.
https://ousurvey.qualtrics.com/jfe/form/SV_0vz8jg1T5yasp1A

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