Social Sciences & Humanities Open 7 (2023) 100410

Contents lists available at ScienceDirect

Social Sciences & Humanities Open

journal homepage: www.sciencedirect.com/journal/social-sciences-and-humanities-open

Regular Article

Associations between environmental factors and adaptive skills of people with intellectual and developmental disabilities in educational settings

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ARTICLE INFO

Keywords:
Environmental design
Adaptive skills
Intellectual and developmental disabilities
Evidence-based design
Autism spectrum disorder

ABSTRACT

This study examines the relationship between environmental factors and target adaptive skills of students with intellectual and developmental disabilities at educational settings. An online survey, which consisted of the Environmental Evaluation (EE) and Performance Measure (PM), was used to measure environmental attributes and target adaptive skills, respectively. This study considered 26 environmental items identified from a systematic review on evidence-based design and evidence-based practice. Factor analyses categorized the 26 environmental items into four components: affordance, restoration, control, and coherence. Multiple regression results supported that the identified environmental items were positively related to students' adaptive skills when their disability levels were controlled (the Environ-Adaptive Skill model; $F (2, 90.13) = 25.363$, $R^2 = 0.278$, $p < .001$). Specifically, restorative features were associated with conceptual/practical skills ($F (2, 383.04) = 31.77$, $R^2 = 0.301$, $p < .001$), and the controllable characteristics were relevant to social skills ($F (2, 37.77) = 12.068$, $R^2 = 0.181$, $p < .001$).

1. Introduction

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 thousand to 7,134 thousand 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 Korean census data have shown an increasing number of people with IDD. The Korean Ministry of Education (Korean Ministry of Education (교육부), 2020, p. 2020) reported that students who receive special education had increased from 82 thousand to 92 thousand in the same period between 2011 and 2019. Among this population, approximately 77.9% 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 threaten 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 create inclusive, enabling environments, where 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 disabling environments has become a social responsibility. Furthermore, the philosophy of universal design, known as "the design of products, buildings, or environments to be useable 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). In the educational sector, Universal Design for Learning (UDL) was introduced to ensure students' access to the general curriculum addressing diverse learners' needs (Edyburn, 2005; Grogan et al., 2000). With the UDL principles developed by the Center for Applied Special Technology (CAST), educational technology and pedagogy have evolved, removing barriers to information representation, students' engagement, and expression (CAST, 2022; Grogan et al., 2000; King-Sears, 2009), Additionally in the architectural sector, the universal design 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

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https://doi.org/10.1016/j.ssaho.2023.100410
Received 7 April 2022; Received in revised form 13 January 2023; Accepted 20 January 2023
Available online 31 January 2023

all users regardless of age or ability (Audirac, 2008).

Along with these philosophical shifts, there have been attempts to legislate social responsibility to define a baseline for minimum accessibility. IDEA started to include specific mandates regarding the accessible curriculum for students with disabilities (Karger & Hitchcock, 2004; McLaughlin, 1999). With continuous efforts, UDL became a part of the Higher Education Opportunity Act of 2008, the U.S. Department of Education's Ed Tech Developer's Guide in 2015, the 2016 National Education Technology Plan, the Every Student Succeeds Act (ESSA), and the Strengthening Career and Technical Education for the 21st Century Act in 2018. The design field also put efforts to ensure the built environment not to discriminate against people with disabilities through the Architectural Barriers Act in 1968, the Americans with Disabilities Act (ADA) of 1990, and the 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 (Salmi, 2007; Yalon-Chamovitz, 2009). The Olmstead decision of 1999 has been mainly 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 (Salmi, 2007; Yalon-Chamovitz, 2009).

1.1. Evidence-based approaches

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 their 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).

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 diverse adaptive skills such as independent learning, daily activities, and social interactions. The environmental features positively associated with students' behavioral skills were: spatial sequencing (Hume & Odom, 2007; Zazzi & Faragher, 2018); environmental cues (Courbois et al., 2013; Hume & Odom, 2007; Pierce et al., 2013); 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, most of the identified strategies have not been supported by a sufficient number of SSEDs. Since prior studies were limited to particular study designs with a 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. According to a systematic review of environmental factors relevant to improved behaviors of people with IDD, twenty-six design strategies for people with IDD were mentioned in twenty EBD studies (Yi, 2021). The design strategies include but are not limited to designing signage or labels with highlights, symbols, non-text components, understandable text, color contrast, and repetition (Ahrentzen & Steele, 2009; Castell, 2012; Gaines et al., 2016; Khare & Mullick, 2009; Lowe et al., 2014; McAllister & Mcguire, 2012a,b; Mostafa, 2010; Salmi, 2007; Sánchez et al., 2011); the use of natural lights, natural scenes, natural features in the environment (Ahrentzen & Steele, 2009; Beaver, 2011; Castell, 2012; Deochand et al., 2015; Gaines et al., 2016; Khare & Mullick, 2009; Lowe et al., 2014; Marchi, 2013; Mostafa, 2010; Nagib & Williams, 2017; Sánchez et al., 2011; Steele & Ahrentzen, 2015; Vogel, 2008; Woodcock et al., 2007); low-arousal environment relevant to visual, auditory, tactile and olfactory stimuli (Ahrentzen & Steele, 2009; Beaver, 2011; Castell, 2012; Deochand et al., 2015; Gaines et al., 2016; Khare & Mullick, 2009; Lowe et al., 2014; Marchi, 2013; Mostafa, 2010; Nagib & Williams, 2017; Sánchez et al., 2011; Scott, 2009); providing expanded personal space, gross-motor area, social area, quiet area, multisensory area (Ahrentzen & Steele, 2009;Beaver, 2011; Deochand et al., 2015; Gaines et al., 2016; Khare & Mullick, 2009; Marchi, 2013; Nagib & Williams, 2017; Sánchez et al., 2011; Scott, 2009; Steele & Ahrentzen, 2015; Vogel, 2008); building design with simple shape, direct route, visual access, compartmentalization, transition, and spatial organization that supports routine (Salmi, 2007; Ahrentzen & Steele, 2009)– (Castell, 2012; Khare & Mullick, 2009; Lowe et al., 2014; Marchi, 2013; McAllister & Mcguire, 2012a,b; Mostafa, 2010; 2014; Sánchez et al., 2011; Scott, 2009; Vogel, 2008). However, there have 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 levels of experts' opinions or reflective experiences. 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.

1.2. Purpose of the study

Therefore, the identified design strategies from EBP and EBD need to be further examined regarding their associations with specific adaptive skills of people with IDD. The presented study aims to test the association between the physical environment and the behaviors of people with IDD. Specifically, this study focuses on 26 environmental attributes as independent variables, which have been identified in the literature, but need to be supported with sufficient evidence. The dependent variable is the adaptive skill that people with IDD could potentially exhibit in their learning environments. By investigating the associations between the enabling environmental features and target adaptive skills, the presented study seeks to prescribe evidence-based design guidelines for people with intellectual and developmental disabilities.

1.3. Research question and corresponding hypothesis

The regression analysis aims to test the following hypothesis.

Question 1: To what extent is a set of design factors related to the adaptive skills of people with intellectual and developmental disabilities (IDD)?

Hypothesis 1. Among people with IDD, a set of enabling design features is related to their adaptive skills when personal factors are controlled.

Once Hypothesis 1 is tested, the associations will be further analyzed between subsets of design factors and subsets of adaptive skills based on factor analysis results.

1.3.1. Assumptions

- 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, as explained by Kurt Lewin's (1936) ecological equation, B = f (P,E), where B is a behavior, P is a person, and E is an environment.

- The variables in the equation, P, E, and B, can be replaced with specific personal or situational characteristics, known as behavior settings (Barker, 1963).
- The Person-Environment (P-E) fit, where a person's needs are congruent with what the environment offers, 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.
- The state of balance (fit) is definable and attainable (Khare & Mullick, 2009; Steinfeld & Danford, 1999)
- Based on the P-E fit model, this study relied on the assumption that the functional independence of students with IDD can be maximized by providing an adequate learning environment (E) in balance with their cognitive functioning (P).

1.4. Definition of variables

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 personal factor (P) to students with IDD, environmental factor (E) to enabling attributes in their learning environments, and behavioral factor (B) to adaptive behaviors.

1.4.1. Enabling environmental attributes

Coherence refers to "clarity or comprehensibility of building elements and form" [52: 87]. Similar concepts include legibility and continuity, while opposite concepts are complexity and 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 use a space or object according to its function adequately.

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). 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 the 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 adverse reactions, like stereotyped, repetitive, self-stimulatory, or other problem behaviors (Marchi, 2013; Steele & Ahrentzen, 2015). Appropriate regulation of social interaction is also essential for people with IDD as they tend to resist having other people close to them (Gaines et al., 2016). Thus, an adequate sensory environment along with alternative sizes and layouts should be considered when designing environments for people with IDD. Control is an environmental characteristic that enables people with IDD to choose or regulate external stimuli according to their needs.

Restoration is a therapeutical feature of an environment that attenuates adverse reactions by providing rest, recovery, or contemplation (Evans & McCoy, 1998). People with IDD are vulnerable to stress and have limited coping strategies. Possibilities are high in people with IDD to show neuropsychiatric symptoms including apathy, depression, anxiety, irritability, agitation, disinhibition, fear, anger, frustration, and sleep disorders (Forlenza et al., 2013; Kazui et al., 2011; Terracciano et al., 2017). 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.

1.4.2. Outcome behaviors

This study's outcome behavior is target adaptive skills, measured by Performance Measure (PM) (Khare & Mullick, 2009). Khare & Mullick (Khare & Mullick, 2009) developed the original PM using shortlisted behaviors that are necessary for independent function in the educational setting and have the potential to be improved by environmental changes. Since the factorial structure of the original PM has not been tested, this study attempts to categorize the PM items with adaptive behavior construct domains.

Adaptive behaviors refer to the skills that people need to function independently in their daily lives (Schalock et al., 2010; 2021; Tassé & Balboni, 2021). 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 – 3rd edition (ABAS 3), the Vineland Adaptive Behavior Scales – 3rd edition (Vineland 3), and the Scales of Independent Behavior – Revised (SIB-R), and the Diagnostic Adaptive Behavior Scale (DABS) (Harris & Greenspan, 2016; Schalock et al., 2021; Tassé & Balboni, 2021; Tassé et al., 2016; 2017). This study considers the three domains of adaptive behavior: conceptual, practical, and social skills (Schalock et al., 2010; 2021; Tassé & Balboni, 2021; Tassé et al., 2012; 2017).

Conceptual Skills are the abilities that deal with abstract concepts and ideas, specifically, language and literacy, money, time, number, and self-direction (Schalock et al., 2010; 2021; Tassé & Balboni, 2021; Tassé et al., 2017). Concerning the interactions between the human and physical environment, this study also considers an understanding of spatial context under conceptual skills.

Practical Skills refer 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 (Schalock et al., 2010; 2021; Tassé & Balboni, 2021). 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 the rules (Schalock et al., 2010; 2021; Tassé & Balboni, 2021; Tassé et al., 2016). The present study also engages social interactions potentially presented in learning environments, including coping, leisure, and play.

2. Method

2.1. Procedure and participants

This study recruited caregivers (e.g. parents, grandparents), educators (e.g. classroom teachers, counselors, special educators), and service providers (e.g. administrators, or others) 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).

The eligibility criteria were determined for the following reasons. In the environmental approach to decreasing 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' assistance in conducting daily performances in educational settings even though environmental support is provided. Meanwhile, the population with mild, moderate intellectual disability has the potential to be independent without caregivers' assistance or with minimal supervision or setup if an adequate environment is provided. Similarly, 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). Therefore, investigating the behaviors of this group is useful to improve the effectiveness of IEP, increasing the success rate of the population's transition to independent living through environmental intervention.

A total sample of 219 educators, caregivers, and service providers was recruited from the United States and South Korea between February 17 and March 24, 2021. Once Institutional Review Board (IRB)'s permission was granted, the research flyer was circulated via relevant organizations' listservs, websites, the weekly newsletter, and social media. The participants were recruited on a voluntary basis. The survey administered in South Korea was translated into Korean and approved by a local community expert organization. In addition, eight experts in special education reviewed the Korean version of the survey to validate if appropriate terms were used and if the questions were contextually understandable. 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.

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%) were 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%), 10–15 years (16.7%), 5–10 years (17.3%), 1–5 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 was 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 ASD, intellectual disability, or both. The majority of educational settings were separate special education schools (41.7%), separate special education classes (29.8%), and service provider locations (7.7%). The characteristics of the sample are illustrated in Table 1.

Table 1
Characteristics of Participants, n = 168.

Respondents' Demographic Information		N	%
Nationality			
	South Korea	139	82.7
	United States	29	17.3
	Total	168	100.0
Relation			
	Special educator	108	64.3
	Classroom Teacher	2	1.2
	Counselor	5	3.0
	Administrator	30	17.9
	Parents	11	6.5
	Grandparents	1	0.6
	Others	10	6.0
	Total	167	99.4
Gender			
	Male	56	33.3
	Female	105	62.5
	Prefer not to say	1	.6
	Total	162	96.4
Work period, if not parents or grandparents			
	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
Student Demographic Information			
Age			
	14	44	26.2
	15	28	16.7
	16	19	11.3
	17	24	14.3
	18	47	28.0
	Total	162	96.4
Gender			
	Male	119	70.8
	Female	37	22.0
	Prefer not to say	7	4.2
	Total	163	97.0
Disability Type (All that apply)			
	Intellectual Disability	121	72.0
	Autism Spectrum Disorders (ASD)	84	50.0
	Others	7	4.2
Disability Level			
	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
Educational setting			
	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

2.2. Instrumentation

A 10-min online survey was developed to test this study's conceptual framework based on the P-E fit model. The survey consisted of two rating scales: the Environmental Evaluation (EE) and the Performance Measure (PM). The EE was used to measure the independent variable of enabling environmental attributes in the learning environment. The PM measured the dependent variable of students' targeted adaptive behavior.

A set of EE and PM, developed by Khare and Mulluck (Khare & Mullick, 2009), was modified for this study's purpose. The original EE and PM set was to assess the environmental impacts on people with 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.

Two types of survey forms were used 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.

2.2.1. Environmental evaluation (EE)

In the first section, the Environmental Evaluation (EE) was presented to quantify enabling features in students' learning environments. The items were based on Khare and Mullick's (Khare & Mullick, 2009) environmental evaluation items as well as the identified items through the systematic review (Yi, 2021). For the adopted survey questions, Cronbach's alpha was used to check internal consistency (reliability),

Table 2
Factor analysis results: 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, 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		
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
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.

and factor analyses were used to test dimensionality (construct validity). Both empirical data and theoretical consideration indicated four-factor subscales for the environmental evaluation (EE): affordance, restoration, control, and coherence (Table 2). 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 a four-component model explained 51% of the total variance. Each of these variables represents the pool of enabling environmental attributes (Cronbach's Alpha = 0.897). 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).

2.2.2. *Performance measure (PM)*

In the second section, this study adopted the Performance Measure for Pupils with Autism (PMPA) to measure students' target adaptive skills and called it the Performance Measure (PM). The PMPA was developed by Khare and Mullick (Khare & Mullick, 2009) to quantify an individual's performance of particular tasks and activities in the context of an educational setting that has undergone environmental evaluation (EE). The use of PMPA is appropriate for this study since the target adaptive skills in the measure were developed in relation to enabling environmental design considerations. As Khare and Mullick (Khare & Mullick, 2009) guided, the questions in the performance measure should be derived from the design parameters in the Environmental Evaluation (EE), based on the assumption that design parameters impact 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 construct domains: conceptual, practical, and social skills (Tassé et al., 2017). Second, ten items were deleted because they were not relevant to this study's scope: design relevant to monitor, maintenance, and safety. Fourth, two items were added: spatial problem-solving under practical skills and following rules under social skills. Finally, the 15 targeted adaptive skill items were determined in the PM. Cronbach's alpha was used to check internal consistency (reliability), and factor analyses were used to test dimensionality (construct validity). Confirmatory factor analyses (CFA) were run using the R package: lavaan and psych (Rosseel, 2012). CFA was initially used to see if the hypothesized construct of the modified instrument was sensible based on the underlying theoretical framework. The model fit was tested for conceptual skill (Purpose, Spatial Context, Interpreting, and Reading Cues), practical skill (Navigation, Problem Solving, Learning Activity, Schedule, Self-Care, and Using Storage), and social skill (Interpersonal, Coping, Following Rules, Play, and Leisure). The model fit indices and cutoff values were chosen to determine the degree of fit between the model and the data. According to Hu and Bentler's (1999) recommendation, the following criteria were used to evaluate the model fit: 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.

Initial confirmatory factor analysis (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 < .001), 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 exploratory factor analysis (EFA) results indicated two-factor subscales for the Performance Measure (PM): conceptual/practical and social skills (Table 3). The social skill items were consistent as hypnotized; however, the conceptual and practical skills were combined as one factor. This result is further addressed in the discussion section. Nine items were used to measure conceptual/practical (Eigenvalue = 4.74, Variance = 0.34), and five for social skills (Eigenvalue = 3.42, Variance = 0.24). Each of these variables represents the pool of adaptive skills necessary to adequately perform at the educational setting (Cronbach's Alpha = 0.942). Each item was scored on a three-point Likert scale (0 = Never, 1 = Sometimes, 2 = Always).

Table 3
Factor analysis results: 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.

2.3. Data analysis

Multiple linear regression was used to assess the associations between environmental attributes and adaptive behavior. Statistical Package for the Social Sciences (SPSS) version 27, in combination with R packages, was used for statistical computing. Survey data were imported and coded. Data measured by the Likert scale were entered as numeric values. regarding the categorical data, the Disability level was coded as 1 = mild disability, 2 = moderate disability.

To deal with missing data, 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. For example, listwise deletion is used for factor analyses, and multiple imputations were implemented to infer missing data for regression analyses. The multiple imputation method replaced the missing values with a set of plausible, predicted values (Kang, 2013). This study dealt with missing data using multiple imputations that Rubin (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).

Multiple linear regression was conducted using the imputed dataset. Before testing the regression model, multiple regression assumptions 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 outliers. Any observations with Cook's Distance values over 1 were regarded as outliers. Finally, multicollinearity was assessed using Variance Inflation Factors (VIF) and tolerance scores. VIF over 10 was considered as the presence of multicollinearity (Menard, 2002).

Once the assumptions were met, stepwise multiple regression was computed using SPSS because this study was interested in the most plausible subset of predictors among environmental and personal factors to explain target outcome behaviors. 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, that is consistently appearing in the original, imputed, and pooled dataset. The stated report is based on the pooled data as the comparison process revealed a similar tendency in the characteristics between the cases with and without missing data (Burton & Altman, 2004; Karahalios et al., 2012) (Table 4). The F-test and *t*-test were reported to show the significance of independent variables. The multiple correlation coefficient, R-squared, was used to determine how much the set of independent variable explain the dependent variables, and the beta coefficients were used to determine the degree of prediction for each independent variable (Statistics Solutions, 2013).

Since SPSS does not provide pooled F and p values for imputed data, 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). SPSS also does not support computing standardized regression coefficients (β) among pooled results. Therefore, the value β was produced by standardizing each imputed data using a descriptive procedure with a split file (IBM, 2020).

To ensure the 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

Table 4
Multiple imputation stepwise regression result.

	Environ-Adaptive Skills Model		Environ-Conceptual/Practical Skills Model		Environ-Social Skills Model	
		β		β		β
(Constant)		24.866 (3.407)		17.631 (2.274)		8.543 (1.285)
First Variable	Environ Attributes	.326*** (.032)	Restoration	.341*** (.070)	Control	.245** (.040)
Second Variable	Disability Level	−.399*** (1.050)	DisabilityLevel	−.420*** (.719)	DisabilityLevel	−.327*** (.434)
R-squared	.278		.301		.181	
Adjusted R-squared	.276		.300		.179	

Note. The report is based on the pooled statistics of multiply imputed dataset.
*, **, *** indicates significance at the 90%, 95%, and 99% level, respectively.
Standard errors are reported in parentheses.

level of 0.05 (Cohen, 2013).

3. Results

3.1. Missing data and multiple imputation

The missing data rate and patterns were analyzed for the two measures, including the Environmental Evaluation (EE) and the Performance Measure (PM). There was no complete variable among the EE and PM items, which means one or more missing data exist for every item. The missing data rate for EE items was 1.8%–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%).

The null hypothesis for Little's missing completely at random (MCAR) was tested. All items in the two measures were entered to the 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 proceed with multiple imputations.

3.2. Stepwise regression

Using the new imputed data, multiple linear regression was conducted to assess how the design attributes are related to the adaptive behaviors of students with intellectual and developmental disabilities (IDD).

3.2.1. H1. Among people with IDD, a set of enabling design features is related to their 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 into the Environ-Adaptive Skill model: environmental attributes and disability level.

The result of regression analysis depicted significant relationships at the 0.01 level, which accepted Hypothesis 1 (H1) (Table 4). There was a significant relationship between environmental attributes, disability level, and adaptive behaviors (F (2, 90.13) = 25.363, $R^2 = 0.278$, $p < .001$). The result showed that environmental attributes (β = 0.326) and disability level (β = −0.399) 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. This result indicated that the more frequent is the presence of environmental attributes listed in the EE, the more frequent is the occurrence of adaptive behaviors listed in the Performance Measure (PM). Additionally, more frequent adaptive behaviors occur as the disability level changes from moderate to mild disability.

Next, the following hypotheses were further tested based on the factorial structure informed by factor analyses on the Environmental Evaluation (EE) and the Performance Measure (PM). Fig. 1 shows the conceptual model of the hypotheses.

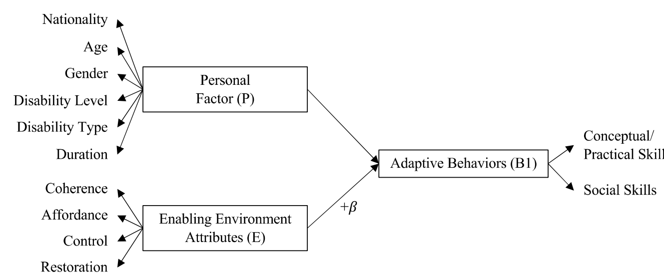

Fig. 1. *Conceptual Model.*

3.2.2. H1a. Among people with IDD, domains of environmental attributes are related to conceptual/practical skills

In the Environ-Conceptual/Practical Skill model, the seven variables, including nationality, student age, student gender, duration, affordance, control, and 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, $R^2 = 0.301$, $p < .001$). The conceptual/practical skills were predicted by the equation, 17.631 + .341(Restoration) – 0.420(DisabilityLevel) (Table 4). Restorative features were measured by the sum score of Natural Light, Tactile, Natural Scene, Olfactory, Naturalness, and Personal Space 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 the more frequent occurrence of target conceptual/practical skills.

3.2.3. H1b. Among people with IDD, domains of environmental attributes are related to 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, $R^2 = 0.181$, $p < .001$). The social skills were predicted by the equation, 8.543 + 0.245(Control) – 0.327 (Disability Level) (Table 4). Controllable features were measured by the sum score of Gross Motor, Quiet Area, Multisensory, Auditory, Assistive Tech, Social Area, 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 occurrences of social skills.

4. Discussion

Multiple imputation regression was used to assess the association between the physical environment attributes and behavioral outcomes. Results of multiple regression analyses supported that a set of evidence-based design guidelines for people with intellectual and developmental disabilities (DG-IDD) is positively associated with a set of target adaptive skills when students' disability level was controlled (the Environ-Adaptive Skill model; F (2, 90.13) = 25.363, R^2 = 0.278, p < .001) (Fig. 2). Specifically, restorative features were associated with conceptual/practical skills (F (2, 383.04) = 31.77, R^2 = 0.301, p < .001) (Fig. 3), and the controllable characteristics were relevant to social skills (F (2, 37.77) = 12.068, R^2 = 0.181, p < .001) (Fig. 4).

The target practical skills (e.g., self-care, problem-solving, learning activity, schedule, etc.) were positively relevant to restorative features in school environments. Restorative attributes in this study measured to what extent each educational setting has access to natural light, scenes, and/or any items (e.g., plants, materials, artwork, etc.) (Ahrentzen & Steele, 2009; Castell, 2012; Deochand et al., 2015; Gaines et al., 2016; Steele & Ahrentzen, 2015), along with comfortable indoor environmental quality (e.g., temperature, air quality, and density) (Ahrentzen & Steele, 2009; Gaines et al., 2016; Kinnealey et al., 2012). This association can be illustrated with the concept of Biophilia, which defines people's innate affinity of the natural world (Kellert & Wilson, 1993). The Biophilia hypothesis has been integrated into the design field as Biophilic design which seeks to integrate natural aspects in built environments. The impacts of Biophilic design have been well-studied in promoting human health, well-being, performance, and productivity (Bolten & Barbiero, 2020; Browning et al., 2014; Peters & D'Penna, 2020). The biophilic concept has been rarely investigated with a focus on a population with IDD; however, the result of this study shows the potential benefit of a Biophilic design for the population.

Controllable environments were positively relevant to social skills. Controllable features in school settings include providing students with diverse choices for social activities and sensory stimuli. These features can be achieved by providing gross-motor areas, quiet areas, social areas, and multisensory areas (Cermak et al., 2015; Lotan & Gold, 2009; Khare & Mullick, 2009; Nagib & Williams, 2017; Steele & Ahrentzen, 2015). The strategies also include the use of assistive technology to control external stimuli for the appropriate level of sensory needs. Sensory integration theory has explained different kinds of sensory perception patterns and dysfunction (Ayres & Robbins, 2005; Miller et al., 2017; Roley et al., 2007). Environmental stressor theory also emphasized the importance of regulating appropriate social interactions for an individual's well-being (Zimring, 1981). Therefore, it is important to create environments that enable one to choose or regulate stimuli to meet individual needs.

Lastly, the combination of affordance, restoration, control, and coherence in the school environments were associated with overall improved target behavioral skills. Based on the empirical data, this study provides a set of evidence-based design guidelines for people with intellectual and developmental disabilities (Table 5). The learning environments with all environmental attributes listed in the guidelines are expected to be positively relevant to students' adaptive skills.

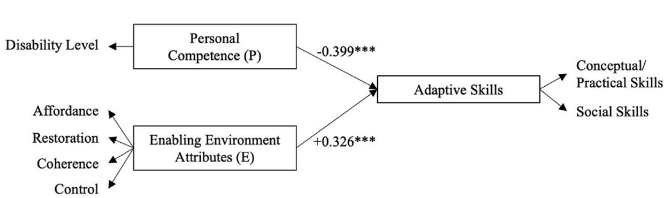

Fig. 2. Environ-Adaptive Skill Model (H1)
Note. Pooled R square = 0.278, adjusted R square = 0.276, pooled F (2, 90.13) = 25.363, p < .001, power = .979 at effect size of 0.15 and alpha of 0.01.

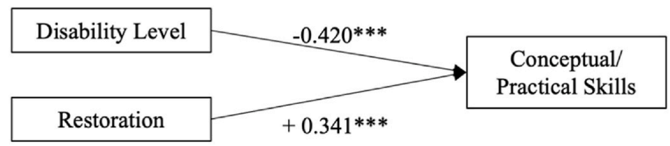

Fig. 3. Environ-Conceptual/Practical Skill Model (H1a)
Note. Pooled R square = 0.301, adjusted R square = 0.300, pooled F (2, 383.04) = 31.77, p < .001, power = .979 at effect size of 0.15 and alpha of 0.01.

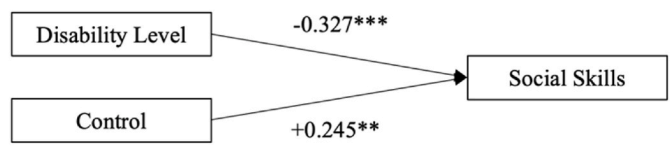

Fig. 4. Environ-Social Skill Model (H1b)
Note. Pooled R square = 0.181, adjusted R square = 0.179, pooled F (2, 383.04) = 12.068, p < .001, power = .979 at effect size of 0.15 and alpha of 0.01.

4.1. Validity and reliability

This research employed an 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, eight experts in environmental design and special education reviewed the operational definitions of this study's constructs. Construct validity is checked by factor analyses and Cronbach's Alpha, which revealed internal consistency of the modified measures.

4.2. Contributions

This study's primary audiences 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.

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. However, 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.

Table 5
Design guideline for people with intellectual and developmental disabilities (DG-IDD).

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.).
Component 3: Control**
The environment enables users to choose or regulate external stimuli according to 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. * Restoration features are positively associated with target conceptual/practical skills in educational settings. **Control features are positively associated with target social skills in educational settings.

4.3. Limitations and future study

The study attempted to categorize the outcome behavior list in Performance Measure (PM) originally developed by Khare and Mullick (Khare & Mullick, 2009) with the three-factor model of adaptive behavior, including conceptual, practical, and social skills (Tassé et al., 2016; 2017). However, the results of CFA did not support this three-factor model, and EFA suggested a two-factor model. According to the EFA result, conceptual and practical skills were combined as one factor among the collected data for this study. The shortlisted skill items in PM were behaviors (1) that could exhibit in educational settings and (2) that could improve by environmental changes. The reason why the three factors were not supported was understandable as there is a relatively low possibility that physical environmental design support conceptual skills. Instead, there are higher chances for practical and social skills to be improved by adequate built-environmental design/-intervention. Thus, the design strategies in the DG-IDD have limitation in supporting the whole aspect of adaptive behavior, but it is relevant to specific target adaptive skills.

Limitations 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. Finding a culturally appropriate way to boost the response rate is recommended. 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 a 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 that 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. Furthermore, the reliability of the study would be strengthened with a bigger sample size.

4.4. Conclusion

The presented study provided a set of design guidelines for people with intellectual and developmental disabilities (DG-IDD), which are positively associated with the adaptive skills of people with 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.

CRediT authorship contribution statement

Ye Ji Yi: Methodology, Formal analysis, Data curation, Writing – original draft, Project administration, Visualization. **Natalie Ellis:** Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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