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Research Paper

A Model of Effective Architectural Variables According to the "Six-factor School Building Checklist" from the High-School Girl Students' Perspectives

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Abstract
Applying an efficient method for studying and assessing school learning space is a considerable issue in Iran country so the main purpose of this research was to introduce a scale utilizing CFA models. The mixed method was used for extracting architectural variables of the learning environment, via a survey study by distributing the six-factor school building checklist consisting of six sub-constructs among the sample of 180 accessible volunteer girl students in Gorgan City (academic year 1397-98). The qualitative study was performed by coding technique to extract some repeated factors for enhancing student achievements from recent research (2017-2022), which includes the effects of green spaces, flexible spaces, daylight, seating arrangement, window view, and outdoor education. According to the quantitative part of the current study, all six factors can describe the six-factor school building checklist and the model fit was achieved and reported as a very good model fit according to CFI (0.93) and RMSEA (0.045) indexes. The factors hierarchically, social space, interface, massing, way-finding, context and finally comfort can determine and describe the main scale. Thirty- three variables among Thirty-eight, can describe the main construct. From the social space factor, the ease of accessibility to the teachers' office, the interface, students' spatial experience from the main entrance to the classroom, the massing, variation in the massing for providing interest, from the way-finding factor, easily understood circulation for interior routes and finally controlling the destructive noise level from the comfort factor reported with the highest factor loadings.

Keywords: *School building, Architectural variables, Assessment, CFA.*

1. INTRODUCTION

1.1. Research Necessity

Researchers have investigated the relationship between physical learning environments and human social-emotional responses (Hughes & Morrison, 2020), little is known about effective factors and variables of physical learning environment, so architectural variables for educational setting improvement extracted in this research can be applied to enhance students' psychological responses. Students are influenced by their surroundings and the physical learning environments can provide healthy conditions or negative ones that shape pupils' behaviors and outcomes. The learning environment is one of the most significant issues from different aspects in developed countries, whereas there is a lack of research in this field in developing ones, such as Iran. Different aspects determine school environments, namely, the physical learning environment or learning space, design facilities, and school culture. The need for creating both efficient and attractive atmospheres for children from the beginning years till adolescence should be paid attention to by programmers and architects as educational environmental designers.

Both qualitative and quantitative dimensions of the physical learning environment should be considered by planners. Therefore, school building study is one of

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the key concepts to determine architectural variables, enhance existing learning environments, and provide choices for appropriate school building design. The lack of information about architectural factors and variables that can determine the quality of school learning space encouraged us to plan research to utilize one of the scales in our local context, Gorgan City where located in northeast Iran to introduce an appropriate scale for school building assessment and setting a priority for variables to be used by architects and future researchers, so this scale can be used by other researchers in other cities of Iran and help architects find out students' needs at the school building design stage.

1.2. Research Objectives

High-school students' unwillingness to spend their time in educational settings and an upper amount of their stress level need a quality-oriented learning space, in which pupils' school connectedness is shaped. The first purpose of the current research was to introduce a standardized scale via reliability and validity discussed in the given sample in the context of Gorgan City, Iran, to help other researchers while studying architectural variables of learning environments and extracting effective variables in line with their factor loadings from students' point of view for designing a new school building or renovation of current ones. This study proposed the following overall hypothesis: the six-factor school building checklist, namely, context, massing, interface, way-finding, social space and finally comfort can describe the main scale, and our research question was about the introduction and priority of these constructs and their variables from the students' perception to use their views for improving educational setting.

1.3. Research Background

There are numerous types of research about studying educational environment, such as topics on students' perception of the learning environment and its effect on student's achievement at the university level (Lizzio, Wilson, & Simons, 2002), perception of school environment associated with academic achievement at elementary and middle school (Gietz & McIntosh, 2014), physical environmental attributes such as seating arrangements, acoustic quality and classroom climate impact on students' behavior and outcome (Tanner, 2009). The quality of the learning environment influences students' engagement (Shernoff & Bempechat, 2014). Students' perceptions of the school environment were associated with students' engagement, hope, and academic outcomes (Van Ryzin, 2011). Students' perspective of the learning environment affected their academic outcome in eighth grade and influence their engagement and identification in seventh grade (Wang & Holcombe, 2010).

According to researchers, there was a link between school conditions and school facilities on students' achievement, dropout rate, and performance (Lumpkin, 2016). There was a link between school facilities and students' outcomes and behavior (Richardson, 2010). Stevenson has argued that school building can have a positive or negative impact on student's performance (Committee, 2001). Building quality has affected students' academic achievements (Durán-Narucki, 2008).

The innovation of this research is studying school environments from architectural observation and assessing the environment from the student's point of view. Also, a standardized scale designed by Sanoff (2001) is utilized to evaluate its validity and reliability in our local context, so it can open doors for other researchers to use this applicable scale, while assessing school building and help designers to apply variables by its priority that were extracted in current research. Besides, extracted variables from the six-factor school building checklist can help researchers to understand users' needs and help designers to decrease second guessing about students' requirements in educational settings. This research is categorized into different parts, namely, a review of literature, material and methods, results and discussion, and finally the conclusion section.

2. LITERATURE REVIEW

2.1. Learning Theories and Learning Environment

Several learning theories link with the learning environment, for instance, Constructivism theory for creating a constructivist learning environment, Social learning theory, and experimental one. Psychological constructivism learning theory is defined as the way people construct their knowledge through experiences. In this case, new learning is reconciled with previous knowledge by students (Oliver, 2000) School setting is a social context, where students can learn from each other and the social learning theory focuses on learning through civilization and the importance of observing and modeling other behaviors (Brady, 2017). In this way, some students' misbehavior can impact on their peers. By the mid-1980s, the social learning theory was known as the social cognitive theory. Experimental learning theory (Kolb, Boyatzis,

& Mainemelis, 2014) defines a situation in which students learn by doing that can be called active learning or interactive one.

2.2. Teacher-centered vs. Student-centered Learning

Teacher-centered learning is a kind of learning in the learning environment authorized and controlled by the instructor and questions are answered by teachers (Emaliana, 2017). In the Student-centered learning process, students are active participants and teachers guide their students in small groups for students' collaboration.

2.3. Space and Learning

There are some new concepts for learning space in the last decades, for instance, "Active Learning Classrooms" (Talbert & Mor-Avi, 2019) to promote students for social interaction and learning in groups and can be used by young children through university-level students. Utilizing moveable furniture, seating that places students in small groups, and easy access to digital tools for learning are some of the design features of active learning space.

These open spaces help students to be more active and interact with their peers and help instructors to be more flexible while teaching topics the mere authorizing and controlling role in teacher-centered learning will be ignored so that students can learn by doing and they ask questions and help each other to find the answers by their teachers' guidance.

Research has shown that open, flexible, and student-centered spaces can improve learners' engagement and active learning (Rands & Gansemer-Topf, 2017).

2.4. Physical Learning Environment/Learning Spaces

Physical learning environments or learning spaces include some elements such as sound, lighting, space, and furniture and the quality of these elements is so important to have a meaningful place.

There is a two-way relationship between students and their learning environment in 21st-century educational settings (Lippman, 2010). A physical space is a place that supports diverse methods of teaching and learning, also a mix of formal and informal learning takes place both inside and outside of the school building. The quality of space is a global debate and for constructing an efficient learning environment, not only technical aspects should be applied, but also the quality of space should be considered (Kuuskorpi & González, 2011). The physical learning environment has an influence on student's motivation and learning (Asiyai, 2014). The quality of school buildings has been linked with aggressive behavior and absenteeism (Schneider, 2002). From research in the traditional learning environment and flexible one among 60 individuals, has been reported that students' engagement and interaction with peers enhanced in flexible classrooms (Kariippanon, Cliff, Lancaster, Okely, & Parrish, 2019). Research on classroom features shows effects on students' performance, indicating that perception of visibility, furniture, and acoustic were more sensitive to air quality, lighting, and room layout (Yang, Becerik-Gerber, & Mino, 2013). Students' achievement and school building condition have been investigated among 199 individuals that indicated a positive relationship between school environment and students' achievement. Some physical features of the learning environment such as window views, lights, indoor air quality, noise, building age, and condition have effects on learning (Roorda, Koomen, Spilt, & Oort, 2011). Flexible furniture, thermal comfort, charming colors, and adequate acoustics are some of the environmental features that should be considered by school building designers (Manca, Cerina, Tobia, Sacchi, & Fornara, 2020).

There are some assessment tools for school building POE evaluation, which are reported in Table 3. For Instance, a study by Hassanian et al. revealed that the design quality indicators (DQIs) can be used as a design tool for proposed school building and facility evaluation of the existing one (Hassanain, Daghistani, & Sanni-Anibire, 2022).

A post-occupational evaluation (POE) has been performed to assess the school building. The POE carried out at Fernando Gasparian High School revealed limitations in the building's design, specifically in light of the neighborhood context, besides, concerns about security and safety (Ornstein, Moreira, Ono, França, & Nogueira, 2009).

Figure 1 shows some repeated factors of physical learning space in recent research by percent, from the review of literature according to the Google Scholar Scientific database from 2017-2022, relevant codes extracted by MAXQDA software, such as green spaces, flexible spaces, seating arrangement, daylighting, color and window views and outdoor education that are discussed as follow:

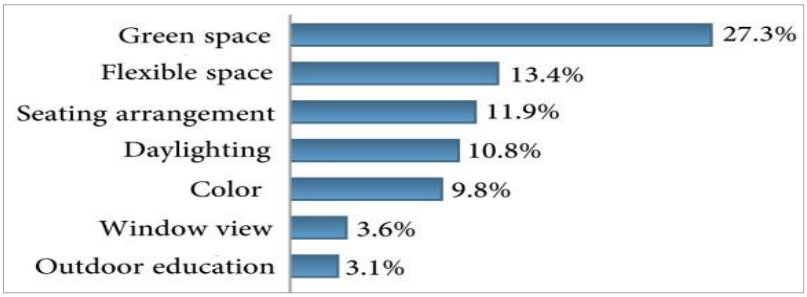


Fig 1. Some repeated factors of the physical learning environment from the recent research (2017-2022)

2.4.1. Green Spaces

Green spaces have a great effect on health benefits, stress reduction, students' cognitive function, depression symptom reduction, well-being, and academic performance (Kweon, Ellis, Lee, & Jacobs, 2017). Outdoor learning and connection to nature had positive effects on students' outcomes and stress reduction (Determan et al., 2019). Views of green spaces can reduce blood pressure and students' progress in learning (Barrett, Treves, Shmis, & Ambasz, 2019). There is a link between green space and students' performance, well-being, and performance (Browning & Rigolon, 2019). Green spaces are associated with health benefits like self-esteem, mental-wellbeing, and cognitive development (Müezzinoğlu, Hidayetoğlu, & Yildirim, 2020).

2.4.2. Flexible Spaces

Flexible spaces have a direct effect on student learning and their motivation and engagement in classroom activities (Adedokun, Parker, Henke, & Burgess, 2017; Barrett et al., 2019; Rands & Gansemer-Topf, 2017). Learning space should provide ease of movement and a thoughtful design of the classroom (Obaki, 2017). Learning environment flexibility plays a vital role in shaping students' engagement in classroom activities (Ahmad & Amirul, 2017).

Students experienced a much better engagement in class activities in flexible learning spaces (Kariippanon et al., 2021; Kariippanon, Cliff, Lancaster, Okely, & Parrish, 2018; Rands & Gansemer-Topf, 2017; X. Yang, Zhou, & Hu, 2022).

2.4.3. Day light

Lighting was effective in elevation student satisfaction (Baum, 2018). Sufficient day lighting is useful for student learning (Barrett, Davies, Zhang, & Barrett, 2017).

Research has investigated how light levels in learning spaces affect the learning process. Daylight from the classroom window impacts anxiety level decrease (Baafi, 2020; Determan et al., 2019; Yin et al., 2020). Physical learning environment attributes such as lighting, temperature, and noise affect student behavior and perception (MÜEZZİNOĞLU et al., 2020). Research has investigated that lighting influences student satisfaction in the learning environment (Hao & Florez-Perez, 2021).

2.4.4. Seating arrangement

Seating arrangement promotes student interaction and it is an effective parameter in elevating student satisfaction (Baum, 2018).

Easy navigation between chairs and movable seating had an impact on student learning progress (Barrett et al., 2019; Rands & Gansemer-Topf, 2017). Seating arrangements affected student achievement (Ahmad & Amirul, 2017). Seating arrangements affect students' engagement and high academic performance (López-Chao, Amado Lorenzo, Saorín, De La Torre-Cantero, & Melián-Díaz, 2020; X. Yang et al., 2022).

2.4.5. Color

The warm and cool colored spaces had a positive impact on students compared to neutral ones. Research reported that warm-colored space influences student behavior Cream colored corridor was perceived more positively from the students' view compared to the blue and green one. Classroom wall color influences pupils' behavior (MÜEZZİNOĞLU et al., 2020).

2.4.6. Window View and Outdoor Education

Views of greenery reduce both stress and heart rate. Outdoor learning is beneficial for students' health and well-being and learning (Browning & Rigolon, 2019).

Table 1. A Summary of Physical Learning Environment Effects on Students' Achievements Materials and Methods

Physical Learning Environment effects	Effects and Relationships	Researchers
Physical Learning Environments effects on students' achievement	Green space and connecting to nature have a great effect on stress reduction and students' performance.	(Kweon et al., 2017)
	Flexible spaces have an impact on student's motivation and learning.	(Adedokun et al., 2017)
	Daylighting influence on students' satisfaction and learning.	(Barrett et al., 2017)
	Seating arrangement influences student engagement and academic performance.	(X. Yang et al., 2022)
	Color has effects on students' behavior.	(MÜEZZİNOĞLU et al., 2020)
	Window view influence on students' stress reduction.	(Browning & Rigolon, 2019)

3. MATERIALS AND METHODS

Both qualitative and quantitative methods are used in current research. The main purpose was to introduce a scale for studying architectural factors of learning settings and extracting variables, and CFA models are used to determine the goodness of model fit to utilize for studying educational settings by architects before school building design and help planners evaluate the physical learning environment.

For the validity and reliability of the scale, Cronbach's alpha for measuring internal consistency, composite reliability, and convergent validity were used. In the current research, 104 samples were proposed by G.Power software with the power of 0.90 for the regression method. According to James Stevens applied multivariate statics, SEM is closely related to multiple regression for some reasons so 15 cases per predictor can be used (Stevens, 2012). The minimum sample size is 100 to 150 for the SEM technique (Ding, Velicer, & Harlow, 1995; Kyriazos, 2018). In this study, a sample of 180 accessible volunteer girl students at the high-school level was used to assess the physical learning environment in three high schools in Gorgan City via a survey study. Observation and distributing a questionnaire called the six-factor school building checklist with 5 point Likert scale and two different kinds of CFA models utilized to determine the goodness of model fit at the first stage and secondly extracted hierarchal variables introduced via second-order CFA models which can illustrate efficient sub-constructs and variables with high factor loadings for describing the main construct. The model for the testing hypothesis is illustrated in Figure 2. An observation report was performed from the architectural point of view, according to the six factors for the sample schools in Tables 5 and 6.

For the qualitative part, variables of the physical learning environment from the recent research were extracted according to the Google Scholar scientific database from 2017-2022 to write the systematic literature review of the current study.

3.1. Research Hypotheses

H1. There is a meaningful correlation between the "context" sub-construct and the scale named, the six-factor school building checklist.

H2. There is a meaningful correlation between the "massing" sub-construct and the scale named, the six-factor school building checklist.

H3. There is a meaningful correlation between the "Interface" sub-construct and the scale named, the six-factor school building checklist.

H4. There is a meaningful correlation between the "way-finding" sub-construct and the scale named, the six-factor school building checklist.

H5. There is a meaningful correlation between the "social space" sub-construct and the scale named, the six-factor school building checklist.

H6. There is a meaningful correlation between the comfort sub-construct and the scale named, the six-factor school building checklist.

3.2. Research Question

Q1. What is the priority of the six factors and their variables of the six-factor school building checklist from students' perspectives?

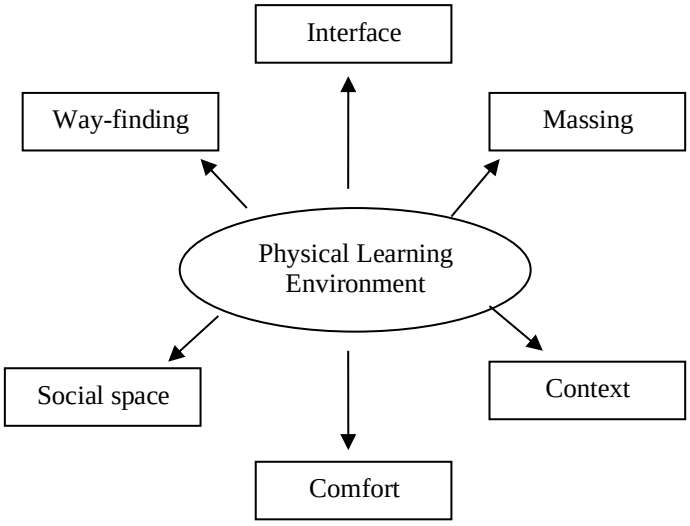


Fig 2. The Model of the Current Research for Testing Hypothesis (Source: Authors)

3.3. *School Building Evaluation*

The POE can be done by one of the studies or a mixed-methods study such as interviews, distributing questionnaires, simulation, and observation. Some developed questionnaires and interview methods were introduced by Sanoff. He encouraged students, parents, teachers, and the local community to participate in the school design and evaluation process (Sanoff, 2001). There are some benefits of post-occupation evaluation of buildings, namely, utilizing good features of current buildings to repeat for future buildings, empowering users to negotiate building issues, identifying problems to reduce and save budget for renovation and future design of other buildings with the same function. Students' needs are important for providing a quality-oriented space and both teaching methods and spaces are significant for school environment improvement. Students and their instructors should participate in different activities and interact with each other, so some teaching methods like small group work and learning by doing need appropriate architectural spaces.

Some scales for physical learning environment assessment are reported in Table 2.

3.4. *The Six-factor School Building Checklist*

School assessment checklist can be used by students, parents, teachers, architects, and policymakers, the six-factor school assessment is a way in which individuals can walk through school buildings to assess views, appearance, circulation, walkways, and orientation (Sanoff, 2001). In the current research, the six-factor school building checklist was used to assess three high-schools in Gorgan City by distributing questionnaires among 180 accessible volunteer female students to assess their school setting (60 individuals from each school). The questionnaire includes six factors or sub-constructs, namely, context, interface, social space, massing, way-finding and comfort. In the following part, the six sub-constructs of the scale were introduced and some previous related studies were discussed (Tables 3 and 4).

3.4.1. Context

The context factor consists of 7 variables as one of the sub-constructs of the scale the six-factor school building checklist, totally about building pattern and its function harmony with adjacent and school buildings scale according to the scale of the school site. Previous studies usually focused on the social context of the school and the structural characteristics, school building size, and its impact on students' behavior. But, the debate on the school building scale and its pattern in relation to neighborhoods have not been widely investigated. Students from low socioeconomic status are benefactors of small schools (Leithwood & Jantzi, 2009). From some previous studies, small high-schools are more beneficial for minority and poor students (Stiefel, Berne, Iatarola, & Fruchter, 2000)

Table 2. Some Scales Description for Physical Learning Environmental/Learning Space Assessment (Source: Authors)

Instrument	Instrument description	
Design Quality Indicators for School	This tool was created in response to the UK Building Schools for the Future (BSF) program for secondary schools in England in 2020.	(Cleveland & Fisher, 2014)
The Facility Performance Profile	To evaluate school facilities, both preliminary designs and existing schools, developed in 1978 by the California Department of Education for designing a new school building	
Relating Objectives to Learning to Education (ROLE)	ROLE was intended to support pedagogical transformation by involving teachers, students, parents, administrators and designers in exploring aspects of the school setting.	(Sanoff, 2001)
The Six-factor School Building Checklist	The six-factor school building checklist: A walking tour is a questionnaire scale to observe and evaluate school buildings.	

3.4.2. Massing

The massing factor consists of 6 variables as one of the sub-constructs of the scale, namely, variation in mass to provide variety and attraction, an appropriate connection between various parts of the building and to the characteristics of the site, subdivided parts of the building appear to have a function and easy to identify and a pleasing appearance caused by the integration of building parts well with each other.

3.4.3. Interface

The interface factor consists of 7 variables as one of the sub-constructs of the scale, namely, Students' experience from the exterior of the building to the interior by means of the main entrance, connecting inside of the building with the outside, easily accessible exits and entrances, various openings in relation to thoughtful planning of the interior, the exits appropriateness from a safety point of view, the exterior of the building to show its interior function and clearness of public and private spaces.

3.4.4. Way-finding

The way-finding factor consists of 7 variables as one of the sub-constructs of the scale includes, easily understood and clearly marked circulation routes of the interior spaces, convenient circulation routes, sufficient routes, pathways, passageways and streets to and around the building, appropriate routes that link the building to its surrounding and the routes arrangement according to busy periods, quiet periods, one- way flows, regular movement patterns and traffic jam.

3.4.5. Social Space

The social space factor consists of 7 variables as one of the sub-constructs of the scale, namely, placing suitable workspace for students' work visualization, the appropriate function of the classroom in relation to other spaces such as small group meetings, classrooms that provide needed privacy for students, furniture arrangement that allows information transformation between peers and a centralized area of information exchange, providing exhibition spaces to display students' work and the accessibility to teachers' office. A previous study found that students were more likely to use comfortable and easily controlled spaces which can provide better communication (Webb, Schaller, & Hunley, 2008).

Designing classroom spaces where students' social interaction occurs is a significant part that should be considered by architects and school building planners. The seating arrangement is important for decreasing students' misbehavior that can influence their attention decrease (Wannarka & Ruhl, 2008).

Classroom design can shape students' behavior, for instance, movable chairs allow students to be closer together for better collaboration and engagement. Providing flexible furniture (Sanders, 2013) and open learning spaces (Graetz & Goliber, 2002) have been investigated in previous studies.

3.4.6. Comfort

The comfort factor consists of 4 variables as one of the sub-constructs of the scale that includes individuals' thermal comfort, ability to adjust thermal comfort on an individual basis, sufficient level of lighting and noise level control in a typical learning space. The level of noise has a relation with students' learning, that is to say, excessive noise has a negative impact on both students and teachers, heat control and appropriate ventilation should be applied for students' performance in the educational setting (Higgins, Hall, Wall, Woolner, & McCaughey, 2005).

Table 3. Reviewing the Literature on the Six Factors of Physical Learning Environment (Source: Authors)

			Sample of educational designs
Context	- site properties: site shape, topography, sub-surface, location and surroundings - Outside education in Edible schoolyard with different gardens	(Woehr, 1973)	 Edible Schoolyard Concept
Massing	- Maximize variation for massing with detailing at the street level to increase pedestrian interest. - Massing can convey meaning while meeting their users' needs - For example: using lights and variation for façade design, East Harlem school	(Sanoff & Walden, 2012) (Salama, 2008)	 East Harlem School

Table 4. Reviewing the Literature on the Six Factors of Physical Learning Environment, Interface, Way-finding, Social Space, and Comfort Factors (Source: Authors)

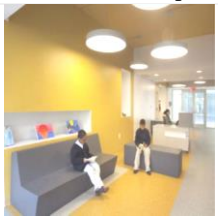
			Sample of educational designs
Interface	- A welcome entry - connections with different parts of the school setting - Higher-education transitional spaces to have better interaction with their peers and teachers	(Nassar & Hosam, 2014)	
Way-finding	- Colors for children's way-finding in the school environment - Building Circulations that significantly influence human behavior - Colors helped both students and adults for way-finding	(Helvacıog & Olguntürk, 2011) (Fu, Liu, & Hon, 2020) (Jansen-Osmann & Wiedenbauer, 2004)	 ROC Graafschap College
Social space	- ACLs or active learning classrooms, a formal place with movable furniture, small group spaces with small whiteboards for social active learning - Collaborative spaces are used for several learning styles - Small group spaces for problem-solving methods in learning to promote intimacy between pupils can be more effective than large group spaces	(Talbert & Mor-Avi, 2019) (Wright, Thompson, & Horne, 2021)	 East Harlem School  Learning Space at the Karolinska Institute
Comfort	Acoustic and noise effects are two important factors, affecting on learning and teaching process (Mateus, Pereira, & Abrantes, 2017). Students' perception of thermal comfort is an important factor in providing comfort in educational settings, there is a link between indoor air conditioning and students' achievement (Haddad, King, & Osmond, 2012). Thermal comfort study is important to discover students' preference toward thermal conditions that have a great effect on students' performance and learning levels (Corgnati, Filippi, & Viazzo, 2007).		

Table 5. School Building Overall Observation Report According to Three Factors (Context-Massing-Interface) from the Architectural View (Source: Authors) SCHOOL C

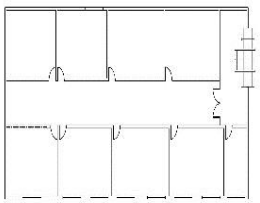
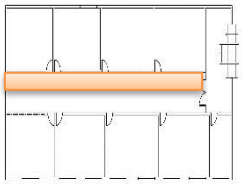
School A	School B	School C
Context		
		
➢ A school courtyard and a basketball playground for students were provided. ➢ The school building suited the pattern of the surrounding building because of the same function.	➢ A small school courtyard with one big tree, small gardens and a basketball playground for students. ➢ There was not a relevant adjacency for the school building, because of the residential buildings around.	➢ A big school courtyard with a basketball playground for students. ➢ The school building suited the pattern of the surrounding building because of the same function.
School A	School B	School C
Massing		
		
➢ Old- aged school building with a rectangular form, surface and rectangular classroom windows that open into the courtyard.	➢ A two-story building, with a rectangular simple white façade. ➢ A colorful glass entrance door and a number of simple rectangular windows.	➢ More aesthetic façade in comparison with the other two buildings. ➢ A variation in windows has been used.
School A	School B	School C
Interface		
		
➢ A simple rectangular plan, corridors were straight for users to walk, ➢ Without any curved space or specific place for refreshment.	➢ No Various openings related to thoughtful planning of the interior ➢ A stair box for access to the second story with 3 classrooms.	➢ Some hidden corners from the main corridor for rooms' location to provide Variation in corridors but without way-guidance for new visitors.

Table 6. School Building Overall Observation Report According to Three Factors (Way-finding-Social space-Comfort) from the Architectural View (Source: Authors)

School A	School B	School C
Way-finding		
		
➢ A long corridor with classrooms is located on both sides.	➢ Simple corridor with an existing door at the end. ➢ Exits appropriateness from a safety point of view	➢ A wide main corridor where classrooms are located on both sides. Some variations and curve openings in the main corridor.
School A	School B	School C
Social space		
		
➢ None-specific views from the classroom windows and none-fixed furniture with the column-row format used for a teacher-centered education.	➢ None-specific views from the classroom windows and none-fixed furniture with the column-row format used for a teacher-centered education.	➢ None-fixed furniture with the column-row format and used for a teacher-centered education. Large windows to receive natural lighting and views of the schoolyard.
School A	School B	School C
Comfort		
		
➢ With simple heaters Without any heat control capability by students.	➢ Using split for air conditioning. A central artificial light and natural light	➢ Using radiators for classrooms and corridors that can be controlled by users.

4. RESULTS AND DISCUSSION

After running the first-order confirmatory factor analysis, the CR>1.96 and P-value=0.00<0.05 was reported for all variables of the six factors, so these variables are statically meaningful. The parameters of model fit, reported CFI=0.90, GFI=0.80, TLI=0.89, and the RMSEA=0.047<0.06 so that a good model fit was achieved.

After running the first-order CFA and achieving a good model fit, the second-order CFA was performed (Figure 3) to calculate the regression weight of sub-constructs for determining the scale and extracting the hierarchical variables of each sub-construct to show the significance of architectural variables of the physical learning environment and introducing them to educational designers.

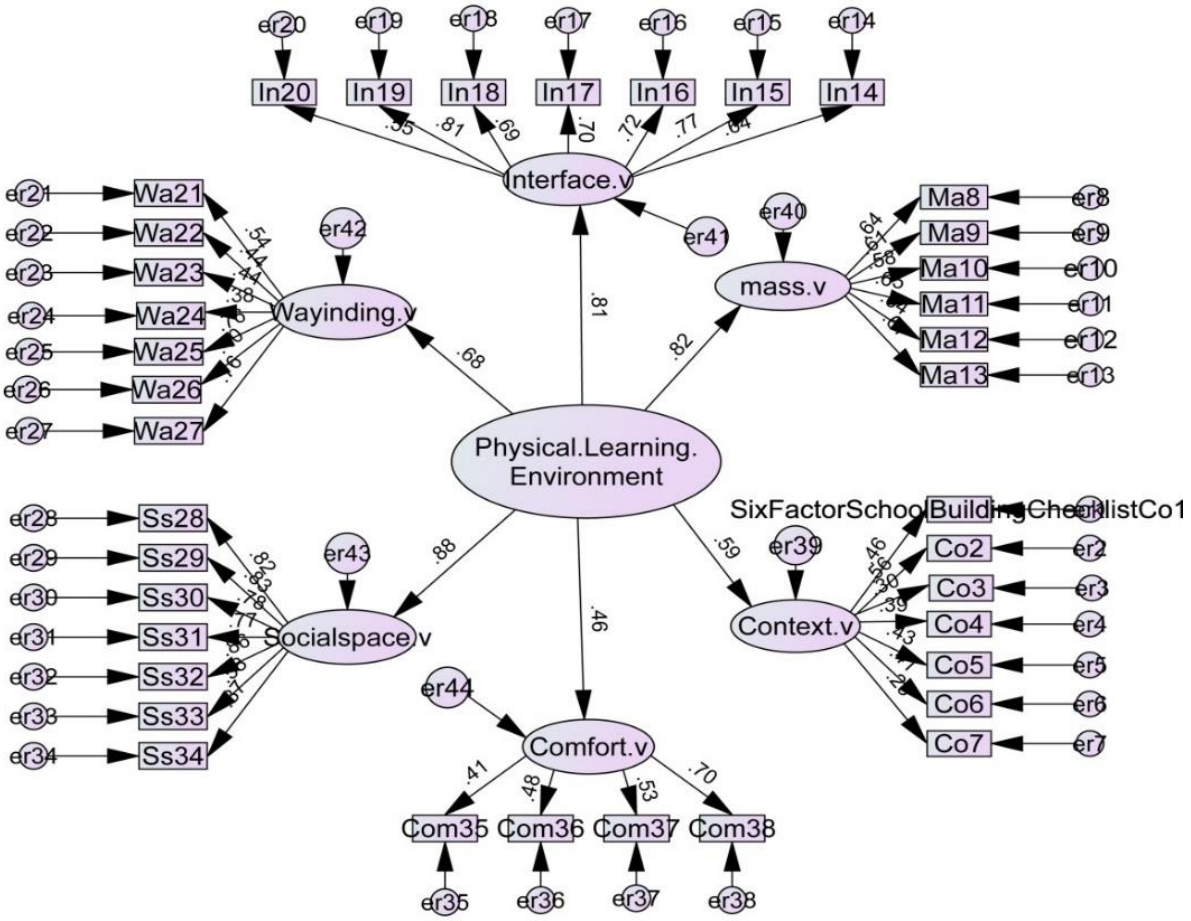


Fig 3. The Second Order CFA Model of the Six-factor School Building Checklist (Source: Authors)

Table 7. The Regression Path Coefficient and Its Significance for the Second-order CFA Model (Source: Authors)

Sub-construct	Path	Construct	Estimate (standardized)	Estimate (Unstandardized)	S.E.	C.R.	P-value	Results
Mass.v	<---	physicalSPace	0.815	0.667	0.094	7.087	0.000	Significant
Socialspace.v	<---	physicalSPace	0.877	1.000		Reference point		
Wayinding.v	<---	physicalSPace	0.681	0.653	0.094	6.957	0.000	Significant
Context.v	<---	physicalSPace	0.592	0.299	0.073	4.097	0.000	Significant
Comfort.v	<---	physicalSPace	0.462	0.393	0.090	4.364	0.000	Significant
Interface.v	<---	physicalSPace	0.815	0.560	0.088	6.404	0.000	Significant

Table 8. Model Fit Indices of the Second-order CFA Model (Source: Authors)

Indices	CMNI/Df	NFI	TLI	GFI	CFI	PNFI	PCFI	RMSEA
Obtained	1.400	0.711	0.887	0.798	0.894	0.666	0.838	0.047

As shown in Figure 3, variables named co3, co4 and co7 from the context sub-construct due to factor loadings under 0.40 and the wa24, wa26 from the way-finding sub-construct omitted for model modification in Figure 4, so that an improvement of model fit indexes achieved (Table 10). Items (Ertz, Karakas, & Sarigöllü, 2016) with factor loading under 0.4 can be omitted. After omitting 3 items of context sub-construct, variables namely, co5 and co6 reported 0. 38 and 0.35, while they are under 0.4 but remained because by removing them the total AVE decreased.

The cumulative AVE for the main construct reported 0.51 with a composite reliability of 0.91 so the validity of the scale was achieved. Also, parameters of the fit index improved after model modification which reported the CFI=0.93, GFI=0.83, TLI=0.92 and the RMSEA=0.045<0.06 (Table 10), which illustrated a noticeable

enhancement in comparison to the previous none-modified model (Table 8).

After modification of the model, all the variables reported a CR>1.96 and the P-value=0.00<0.05 (Table 11), showing that the scale adopted with the context and can be used for assessing school building by other researchers in different contexts of Iran.

For the validity and reliability of the scale, Cronbach's alpha for measuring internal consistency, composite reliability and convergent validity used, reported The Cronbach's alpha for each factor, namely, social space (0.92), interface (0.87), massing (0.80), way-finding (0.73), context (0.57), and comfort (0.61). Composite reliability of social space was 0.94 and the AVE 0.62, CR (0.92) and AVE (0.49) for interface, CR0 (0.87) and AVE (0.40) for massing sub-construct, CR (0.86) and AVE (0.37) for way-finding, CR (0.72) and AVE (0.30) for context and finally Cr (0.70) and AVE (0.76) for comfort sub-construct, also the CR (0.91) and AVE (0.51) for the scale, which reported as a reliable and valid scale.

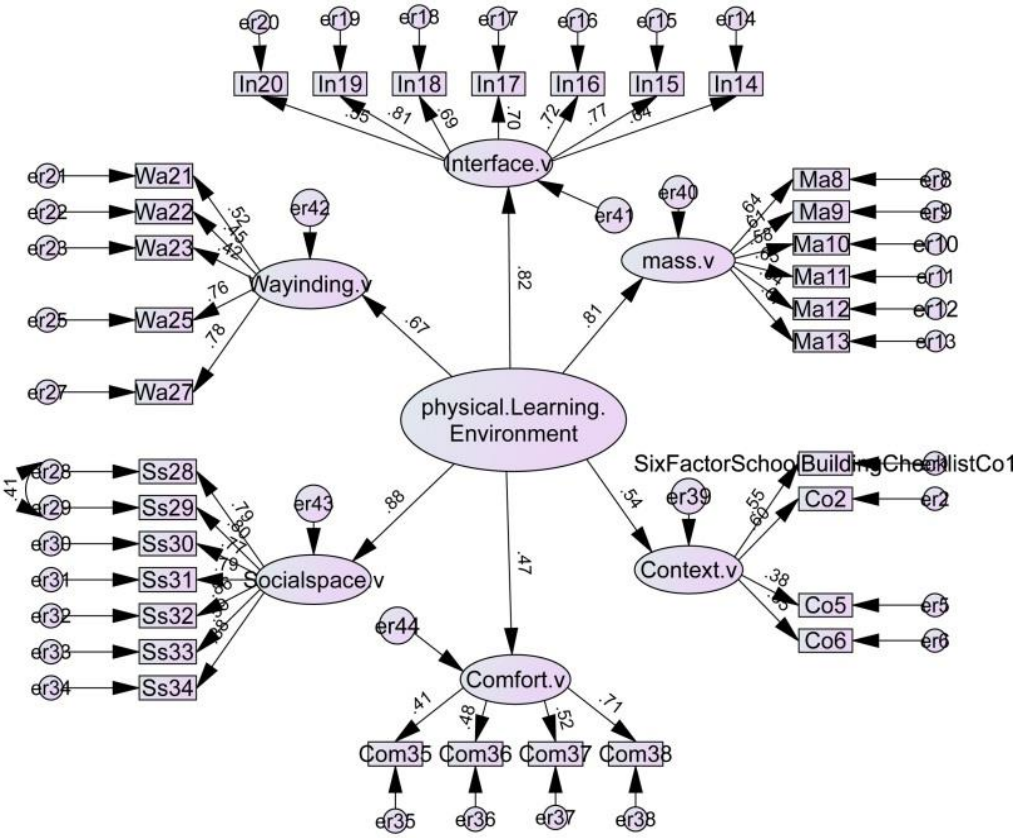


Fig 4. The Modified Second-order CFA Model of the Six-factor School Building Checklist (Source: Authors)

Table 9. The Standardized Regression Weights and Its Significance for the Modified Second-order CFA Model (Source: Authors)

Sub-construct	Path	Construct	Estimate (standardized)	Estimate (Unstandardized)	S.E.	C.R.	P-value	Results
Mass.v	<---	physicalSPace	0.812	0.651	0.092	7.087	0.000	Significant
Socialspace.v	<---	physicalSPace	0.883	1.000		Reference point		
Wayinding.v	<---	physicalSPace	0.669	0.648	0.093	6.939	0.000	Significant
Context.v	<---	physicalSPace	0.537	0.320	0.078	4.106	0.000	Significant
Comfort.v	<---	physicalSPace	0.467	0.392	0.089	4.421	0.000	Significant
Interface.v	<---	physicalSPace	0.818	0.552	0.086	6.428	0.000	Significant

Table 10. Model Fit Indices of the Modified Second-Order CFA Model (Source: Authors)

Indices	CMNI/Df	NFI	TLI	GFI	CFI	PNFI	PCFI	RMSEA
Obtained	1.357	0.769	0.919	0.825	0.925	0.711	0.855	0.045

From the results, all six sub-constructs and 33 variables among 38 can determine the main construct. From the students' perspectives, social space, then hierarchically interface, massing, way-finding, context, and comfort with the standardized regression weight of 0.88, 0.82, 0.81, 0.67, 0.54, and 0.47 are the sub-constructs that can introduce the physical learning environment scale, so all the six hypotheses approved. It can be concluded that there are 4 variables among 7 the context factors such as the suitable scale of the building in relation to the site, an appropriate building pattern in relation to the surrounding streets, the land uses adjacent to the building fitting harmoniously with the building, and finally, the school building and its intended use fit well with the type and uses of adjacent buildings, and 5 variables among 7 determined the way-finding factor. Also, other sub-constructs with their hierarchical variables are reported in Table 11. The variables extracted in the current research with the high factor loadings from the six sub-constructs of the school building checklist are shown and discussed in line with previous studies in the following paragraphs:

From the social spaces sub-construct with 7 variables, according to Table 11, the easy access to teachers' offices with a factor loading of 0.88 was reported with the highest factor loading among others, then the building arrangement for a centralized information exchange reported 0.86. Hence, an efficient teacher-student social relationship with easy access to teachers' offices should be considered first. Designing classrooms that are linked with small groups and project spaces (0.80) is another important variable that can help students with better collaboration. Students' ability to personalize their workplace and appropriate building arrangements for student-teacher relationships reported 0.79 factor loading and classroom arrangement for providing privacy for students can be considered significant variables of the social space sub-construct.

An appropriate classroom is a place with a high ceiling and few walls with flexibility and mobility for students' better communication (Warner & Myers, 2009). According to the obtained results, classroom design with small groups and providing individual pursuits at the high-school level should be considered.

In 21st-century pedagogy, there are new methods of teaching and learning such as learning by doing so that the authorizing teachers' role hidden, easy access to teachers' offices and providing a place for more teacher-student interaction in a more kind way should be significantly mentioned.

From the interface sub-construct with 7 variables according to Table 11, the students' experience from the exterior of the building to the interior by means of the main entrance with a factor loading of 0.81 reported the highest factor loading among other variables of the interface sub-construct. So, the spatial experience is important for school building design. In this case, school landscape design has a great influence on better students' spatial experience, proper landscape design from the main entrance to the learning space, and appropriate integration of learning space with nature or artificial natural elements can be used for providing this spatial experience. According to variable number 15 appropriate connection between inside and outside of the building with a factor loading 0.77 was found to be providing gardens and natural zones outside of the building in relation to interior spaces that can significantly improve the educational setting quality at the high-school level that students may encounter with more stressful conditions. Attention restoration theory suggests that students' exposure to natural environments is associated with stress levels and mental fatigue decrease (McCullough, Martin, & Sajady, 2018).

From the massing sub-construct with 6 variables, according to Table 11, the first variable which is variations in the massing to provide interest and variety with a factor loading of 0.67 reported the highest factor loading among other variables. The aesthetic features of school buildings can provide a sense of belonging to the school setting and can enhance learning (Jarman, Webb, & Chan, 2004).

From the way-finding sub-construct with 5 variables, according to Table 11, the first variable which is the interior circulation routes clearly marked and easily understood with a factor loading of 0.78 reported the highest factor loading among others. So, a sense of clear entrance, appropriate circulation, and pathways are important aspects of the physical learning environment.

The physical learning environment to improve students' outcomes is defined by four elements such as circulation and movement, large group meeting space, day lighting and views and instructional neighborhoods (Tanner, 2008).

From the context sub-construct with 4 variables, according to Table 11, the first variable which is the scale of the building that suits the site scale with a factor loading of 0.60 reported the highest factor loading among others.

From the comfort sub-construct with 4 variables according to Table 11, the first variable which is controlling the distractive noise level in a typical learning space with a factor loading of 0.71 reported the highest factor loading among others.

It is shown that that higher environmental noise levels decrease learners' attention (Zhang, Zhang, & Kang, 2018). Noise level and an appropriate temperature are significant for efficient student performance (Earthman, 2002).

Previous studies have investigated that there was a relationship between school building conditions and learners' performance (Gunter & Shao, 2016). There was a relationship between building conditions and students' attitudes and teachers' performance (Peterson, 2014). School building conditions are related to students' academic outcomes in Pennsylvania high schools (O'Sullivan, 2006). School facility conditions and maintenance such as conditions of lockers and cleaning classrooms influenced higher reading scores among elementary and high school students (Lewis, 2000). So, school building conditions and variables extracted in the current research should be utilized in school building design to improve students' performance.

Table 11. Extracted Hierarchical Sub-constructs and Variables of the Six Factor School Buildings Checklist (Source: Authors)

Sub-constructs	Factor loadings	Thirty-three variables, according to their factor loadings	C.R.	P-value	Factor loadings
1. Social spaces	0.883	34. Easy access to teachers' office	Reference point		0.879
		32. Building arrangements for a centralized area of information exchange	15.778	0.000	0.864
		29. Classroom relationship with small group meeting and project space	13.601	0.000	0.798
		28. The building suits the students' ability to personalize their workspace	13.314	0.000	0.788
		31. Building arrangements for casual contact among students and teachers	13.279	0.000	0.785
		30. Classroom-appropriate design for needed privacy or individual pursuits	12.905	0.000	0.772
		33. Exhibition spaces to display Students' work	8.797	0.000	0.594
2. Interface	0.818	19. Students' experience from the exterior of the building to the interior by means of the main entrance	7.404	0.000	0.811
		15. The inside of the building connects with the outside of the building	7.194	0.000	0.767
		16. Easily accessible exits and entrances.	6.971	0.000	0.724
		17. Various openings relate to thoughtful planning of the interior	6.844	0.000	0.702
		18. The exits appropriateness from a safety point of view	6.754	0.000	0.686
		14. Pleasing appearance of well-integrated building parts from the outside	6.485	0.000	0.642
		20. Clearness of public and private spaces.	Reference point		0.547
3. Massing	0.812	13. Variations in the massing provide interest and variety	7.267	0.000	0.672
		11. The various parts of the building are planned carefully in relation to one another and to the characteristics of the site.	7.084	0.000	0.650
		12. The relationship between the parts of the building makes it appear as one unified structure.	7.005	0.000	0.641
		8. Well-integrated parts of the school building form a pleasing appearance from the outside view.	Reference point		0.637
		9. The subdivided parts of the building appear to have a function that is easy to identify	6.734	0.000	0.609
		10. Various parts of the building are clear for visitors.	6.487	0.000	0.582
4. Way-finding	0.669	27. The interior circulation routes are clearly marked and easily understood	Reference point		0.778
		25. Understandable and convenient circulation routes	8.726	0.000	0.758
		21. Sufficient routes, pathways, streets and passageways provided to and around the building	6.283	0.000	0.520
		22. The routes link the building to the surrounding buildings or structures.	5.444	0.000	0.450
		23. The routes are arranged to consider busy periods, quiet periods, one-way flows, regular movement patterns, and traffic jams.	5.087	0.000	0.421
5. Context	0.537	2. The scale of the building suits the site scale.	4.110	0.000	0.597
		1. The building suits the pattern of the surrounding streets.	Reference point		0.549
		5. The land uses adjacent to the building seem to fit harmoniously with the building.	3.335	0.000	0.379
		6. The school building and its intended use fit well with the type and uses of adjacent buildings.	3.180	0.001	0.351
6. Comfort	0.467	38. Controlling the distractive noise level in a typical learning space.	Reference point		0.706
		37. The light levels in the building support learning spaces.	4.652	0.000	0.524
		36. There is an ability to adjust thermal comfort on an individual basis.	4.441	0.000	0.481
		35. The learning spaces in the building suit an individual's thermal comfort.	3.961	0.000	0.407

Fig 5. Hierarchical Data Illustration Diagram of the Sub-constructs and Variables of the Six Factor School Buildings Checklist from the Students' Perspectives (Source: Authors)

5. CONCLUSION

The findings of the study indicated that the six-factor school building checklist is a reliable and valid scale for studying architectural variables of the learning environment and can be used by other researchers in the Iran context also concluded that there is a priority for these factors and variables of the scale from the students' perspective as the main users of the school building, that is to say, social space then the interface factor and hierarchically massing, way-finding, context, and comfort can determine the scale by their variables. According to the hierarchical variables of each sub-construct, reported that from the social space, firstly the students' accessibility to their teachers' office while they need to have better communication with their instructors, then the building arrangements for information exchange and the small meeting space and needed privacy in relation to classroom space also a place for students' work visualization should be considered by designers due to students' needs at the stage of planning.

From the second sub-construct which is the interface, it was found that students' experience from the exterior of the building to its interior from the main entry and the efficient connection of the interior to the exterior should be considered. In this case, architects can design a classroom plan with easy access to the exterior environment or bring nature into interior spaces.

From the massing sub-construct, the variation and unified appearance of integrated different parts of the school building should be visually pleasing to students' perception. In this way, architects should set an interview with students to know their preferences. From the interview in our study, most of the students preferred curved forms for school building overall mass. A good mass design should consider the students' preferences, climatic conditions of the context and spatial connections from the architectural perspective. Clearly and easily understood circulation for students and the building scale which suits the site scale and school building pattern harmony with adjacent buildings. Finally, students' ability to control the heating condition of learning environments and a controlled level of noise should be considered by school building designers at the stage of planning for design and these criteria mentioned from the results, creates a second home for students and can enhance their academic performance.

Some recommendations to improve physical learning environments according to the obtained results are as follows:

Social space design: Providing the ease of accessibility to teachers' offices and designing an office with public zones, where students can better interact with their teachers. A centralized space for learning such as a collaborative studio for student-oriented learning should be designed.

Interface design: Providing a flexible environment for students' interaction with their peers is important for improving a sense of belonging. From the results, firstly improving the spatial experience for students from the main entrance to the classroom utilizing designing site elements such as a canopy, suitable paving with grass blocks instead of asphalt, gardens and flower box design, linking between inside and outside via semi-open spaces should be considered.

Massing design: Providing a Y or U shape design for schools located in northeast Iran such as Gorgan City for sports fields and green open spaces, instead of a closed configuration. Variations of mass and well-integrated parts should be applied to provide interest for students and other occupiers.

Way-finding: Providing easily-understood interior routes and sufficient pathways, streets, and passageways. For this purpose, there should be a separation between pedestrian crossing and vehicular routes. Instead of asphalt for paving, using green grass blocks for more greenery can be an applicable way.

Context design: Utilizing the pattern of surrounding buildings and school building scale adjustment to site scale are significant. For designing the school building in the site plan, considering building orientation to allow airflow through the building in Gorgan City due to climatic conditions should be considered.

Comfort: Controlling the destructive noise level in learning spaces can be achieved by building a massing design that links with green spaces and appropriate distance from the main streets. the appropriate light level for learning space, providing individual thermal comfort with an ability to adjust thermal comfort on an individual basis, which can be applied by controlling the thermal comfort zone from the students' perception in a specific period of time.

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