

Identification of criteria for evaluating school buildings

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ABSTRACT

The objective of this research is to identify which criteria should be considered in the evaluation of school buildings, through a systematic review of the literature, consultation of government standards and guidelines and consultations with experts. The research was carried out in 3 stages: 1) systematic review of the literature, 2) review of national standards and guidelines to identify criteria, and 3) weighting of criteria through the application of the Delphi method. 70 evaluation criteria were identified, which were grouped into 11 categories and weighted through consultation with experts. The identification of criteria as presented in this research, aims to contribute to the development of techniques and evaluation methods, to later compose a performance standard for school buildings.

Keywords: school infrastructure; performance of school buildings; school building evaluation criteria; systematic literature review; delphi.

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Contribution of each author

In this work, the 1st author contributed with the activities of applying the Delphi technique and discussion of the results, the 2nd author with the literature review activity, the 3rd author contributed with the original idea and direction of the research, and the 4th author contributed with the selection of specialists and review of regulations.

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Identificación de criterios para la evaluación de edificios escolares

RESUMEN

El objetivo de esta investigación es identificar qué criterios se deben considerar en la evaluación de edificios escolares, a través de una revisión sistemática de la literatura, consulta de normas y directrices gubernamentales y consultas a expertos. La investigación se llevó a cabo en 3 etapas: 1) revisión sistemática de la literatura, 2) revisión de normas y directrices nacionales para identificar criterios y 3) ponderación de criterios mediante la aplicación del método Delphi. Se identificaron 70 criterios de evaluación, los cuales fueron agrupados en 11 categorías y ponderados mediante consulta a expertos. La identificación de criterios, tal como se presenta en esta investigación, tiene como objetivo contribuir al desarrollo de técnicas y métodos de evaluación, para posteriormente redactar una norma de desempeño para edificios escolares.

Palabras clave: infraestructura escolar; desempeño del edificio escolar; criterios de evaluación de edificios escolares; revisión sistemática de literatura; delphi.

Identificação de critérios para avaliação de edificações escolares

RESUMO

O objetivo desta pesquisa é identificar quais critérios devem ser considerados na avaliação de edifícios escolares, por meio de uma revisão sistemática da literatura, consulta a normas e diretrizes governamentais e consultas a especialistas. A pesquisa foi realizada em 3 etapas: 1) revisão sistemática da literatura, 2) revisão de normas e diretrizes nacionais, para identificação dos critérios e 3) ponderação dos critérios, por meio da aplicação do método Delphi. Foram identificados 70 critérios de avaliação, que foram agrupados em 11 categorias e ponderados por meio da consulta a especialistas. A identificação dos critérios conforme apresentado nesta pesquisa, visam contribuir para o desenvolvimento de técnicas e métodos de avaliação, para posteriormente compor uma norma de desempenho para edifícios escolares.

Palavras-chave: infraestrutura escolar; desempenho de edifícios escolares; critérios de avaliação de edifícios escolares; revisão sistemática da literatura; delphi.

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1. INTRODUCTION

The school environment and indoor spaces play a significant role in improving or obstructing teaching and learning processes. Well-designed, properly furnished and maintained school facilities contribute to better academic performance which positively reflects on student development (Hassanain; Ali Iftikhar, 2015).

As pointed out by Cardoso (2017), school infrastructure planners are faced with a scenario in which there is a need to create a comfortable and stimulating space for children. However, considering the Brazilian economic limitations, a transformation of this reality can be only with the construction of new units, so it is necessary to define strategies for the adaptation of existing buildings.

National and international studies point to many deficiencies in relation to the maintenance and conservation of school buildings (Norazman, Norsafiah, et al., 2019; Marques, De Brito, Correia, 2015; Mojela, Thwala; 2014; Mydin et al., 2014; Tan et al., 2014; Ali et al.; 2013; Shehab, Nouredine 2013; Soares Neto et al., 2013; Boothman, Higham, Horsfall, 2012; Asiya, 2012; Gomes and Regis; 2012)

Beauregard and Ayer (2018) highlight the importance of establishing a process to prioritize the installation maintenance work orders, thus seeking to optimize public resources. Therefore, the selection of the criteria to be evaluated becomes the first step to obtain this prioritization of the conservation activities of the schools.

The identification of criteria for evaluating buildings is a recurring theme in case studies related to quality control, pathology and building recovery, such as the research by Sotsek, Leitner and Santos (2019). As pointed out by Koleoso et al., (2013), measuring the performance of a building is the safest way to improve the economic, physical and functional development of a building, ensuring that its objectives are met.

Based on this scenario, this article aims to identify which criteria should be considered in the evaluation of school buildings, through a systematic review of the literature, consultation of national and international standards and consultations with specialists, aiming at the conservation of these buildings and guaranteeing the proper performance.

2. STANDARDS AND GUIDELINES FOR EVALUATING SCHOOL INFRASTRUCTURE IN BRAZIL

In Brazil, there are no specific standards for evaluating a school's infrastructure. However, there are rules for evaluating buildings in general, which can guide the evaluation of a school building. These standards are drawn up by the Brazilian Civil Construction Committee (ABNT/CB-002), which is responsible for standardizing the sector.

The main building evaluation standard is ABNT NBR 15575 (2013), “Performance of housing buildings”, which establishes the requirements and performance criteria that apply to housing buildings, seeking to meet user requirements that are: safety, habitability and sustainability.

This standard, however, does not apply to works in progress or buildings completed by the date of entry into force, nor to renovations, retrofits and temporary buildings.

In addition to ABNT NBR 15575 (2013), other standards that address the performance of buildings are ABNT NBR 14037 (2014) “Guidelines for the preparation of manuals for the use, operation and maintenance of buildings – Requirement for the preparation and presentation of contents”, ABNT NBR 5674 (2012) “Building maintenance – Requirements for the maintenance management system”, and ABNT NBR 16280 (2015) “Building renovation – Renovation management system – Requirements”.

Recently, another standard was elaborated, ABNT NBR 16747 (2020), "Building Inspection - Guidelines, concepts, terminology, requirements and procedure", which provides guidelines, requirements and procedures related to building inspection, aiming to standardize methodology, establishing methods and minimum steps of the activity. The standard will apply to buildings of any type, public or private, for global assessment of the building, fundamentally through sensory examinations by a qualified professional.

The "Prova Brasil" and the School Census have been the methods used to assess a school's infrastructure in terms of learning and performance.

The "Prova Brasil" is a census assessment, created by the National Institute of Educational Studies and Research (INEP) in 2005, to assess the quality of education offered by the Brazilian public education system; through standardized tests in the areas of Portuguese Language and Mathematics, it provides data for Brazil, federation units, municipalities and participating schools. In addition to the tests, students also answer a questionnaire on aspects related to socioeconomic and cultural origin and on school and study practices. Principals and teachers also respond to questionnaires involving aspects related to school resources, school organization and management, academic climate and pedagogical practices (Gomes and Regis, 2012).

In this test, the state of conservation of the items and equipment of the building (roof, walls, floor, entrance of the building, patio, corridors, classrooms, doors, windows, bathrooms, kitchen and hydraulic and electrical installations are evaluated, but it does not evaluate stairs, ramps and elevators, among others...), the number of classrooms that meet the criteria for adequate lighting and ventilation, aspects related to the safety of schools and students, among other aspects.

The School Census, on the other hand, offers different information about the school reality, presenting data on schools, classes, enrollment and teachers. Although these data are important, by themselves they would not reveal the state of conservation of the schools, since the infrastructure variables available in the School Census only indicate the presence or absence of certain items.

The School Census (INEP, 2019) is applied annually throughout Brazil, collecting information on various aspects of Brazilian schools, in particular enrollment and infrastructure. All levels of education are involved: kindergarten, elementary school, high school and Youth and Adult Education (EJA). Infrastructure data is divided into seven sections: power; services; dependencies; equipments; technology; accessibility and others.

3. METHOD

The development of this research was carried out in three different stages, as shown in Figure 1.

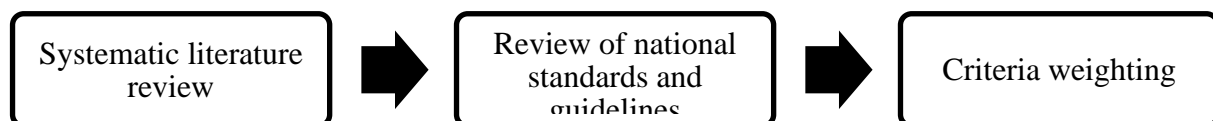


Figure 1. Steps of the research. Source: The authors.

3.1 Step 1

First, a systematic literature review (SLR) was conducted on scientific articles, seeking to identify which criteria for evaluating the performance of school buildings were most relevant in the academic environment. According to the research by Sampaio (2007), the following parts were defined to conduct the literature review:

- 1) Definition of the question - what criteria are used to evaluate the performance of educational buildings?
- 2) Searching for references – characterized by the definition of keywords and search strategies, in addition to the identification of the databases to be consulted. Table 01 shows the search strategies adopted. The search was carried out in four different databases, and limited to results in English and Portuguese. In addition, the search was restricted to finding the term only in the title, abstract and keywords of the documents.

Table 1. Search terms, sources used and respective results. Source: The authors.

Search Terms	Source	Results
“Educational Building Performance”	Scopus	88
	Periódicos CAPES	23
	Scielo	21
	Science Direct	188

3) Reviewing and selecting the studies - Based on the results found previously, the titles of documents that did not fit the criteria defined for conducting the research were evaluated and eliminated. The summaries of the remaining articles were then analyzed and those that dealt with performance in educational buildings were selected. Then the repeated documents were excluded, and the rest of the articles were read in full. The final selection excluded documents that did not include criteria and parameters for analyzing the performance of buildings. Through the backward procedure, in which the references of previously selected studies are consulted (DRESCH et al, 2015), one more article was added to the review.

After the selection of the studies, an analysis was carried out in order to identify the criteria addressed in the research to evaluate the performance of the school building. The data obtained are exposed in the results section.

3.2 Step 2

After analyzing the academic works consulted in the SLR, it was found by the authors that it would be necessary to carry out a more comprehensive search to identify which criteria should be used for the evaluation of school buildings. To complement the research, the following were also consulted:

- National standards; (references to international standards have been removed, based on the evaluators' suggestions)
- Federal and state government guidelines;
- Assessment instruments for Brazilian schools;

The presentation and synthesis of the results obtained are also addressed in the Results and Discussion section.

3.3 Step 3

In order to build a more consistent criteria framework, the Delphi method was also applied, in which specialists who work or worked as engineers in city halls are presented in Table 2. The objective of this step was to make the specialists reach a consensus on the importance of the previously identified criteria and assign grades to the criteria.

Table 2. Profile of the specialists who participated in the Delphi stage. Source: The authors.

Specialist	Occupation	Working time with performance of school buildings
A	Construction supervisor	Less than 1 year
B	Construction supervisor	Less than 3 years
C	Civil engineer	Less than 3 years
D	Construction Secretary (Retired)	More than 3 years
E	Civil Engineer I	Less than 1 year
F	Infrastructure supervisor	More than 08 years

To decide whether or not there was consensus after each round, equation (1) was used. (WILSON; PAN; SCHUMSKY, 2012):

$$CVR = (NE - N/2)/(N/2) \quad (1)$$

where:

CVR = Content Validity Ratio;

NE = number of experts who indicate that a parameter is essential; and

N = total number of specialists participating in the survey.

Consensus was considered when the CVR was greater than or equal to 0.29 and the method rounds were stopped. The technique was applied through online questionnaires, in three rounds. In the first one, the specialists received a questionnaire with the list of criteria obtained in the previous step, and they should indicate their importance on a scale from 1 to 4 (where 1 means little important and 4 very important). This scale was adopted to avoid the intermediate neutral term (3), from the five-point scale, which in previous experiences has shown to be an option for indecision in questionnaires. If they judged that the criterion was not relevant in the evaluation, it was possible to mark the option N/A (not applicable). In the second round, the averages obtained through the previous questionnaire were presented, and the experts were invited to reassess some criteria, whose consensus was not obtained in the first round. Finally, the third round presented the results obtained in the previous stage and, only for the criteria where there was still no consensus, a new reassessment was carried out.

4. RESULTS AND DISCUSSION

4.1 Step 1

This stage of the work is based on the results of the literature review on the important criteria for the evaluation of school units. The academic works consulted, resulting from the literature review, are listed in Table 3, according to the identified criteria.

Table 3. Articles consulted in the Literature Review. Source: The authors.

References	Criteria
Michael, Heracleous (2017)	Lighting levels, light distribution, visual comfort conditions, need to use artificial lighting
Khalil et al. (2016)	Spaces, window orientation, infrastructure, accesses, circulation areas, ergonomics, signs, emergency exits, probability of user contamination, common areas, materials, structural stability, information systems in building automation, electrical and plumbing services, prevention fire, roof, elevators, thermal comfort, artificial and natural lighting, garbage disposal, ventilation, acoustic comfort, cleaning
Driza, Park (2013)	Performance of water and electrical systems
Khalil et al. (2012)	Accessibility in buildings, location, users' perception of building problems
Mijakowski, Sowa (2017)	Indoor ventilation, temperature, humidity and CO2 concentration
El Asmar et al. (2014)	Layout, furniture, thermal comfort, indoor air quality, lighting, acoustic comfort, hydraulic efficiency, cleaning and maintenance
Zomorodian, Tahsildoost (2014)	Thermal and visual comfort
Bonomolo et al. (2017)	Natural lighting
Pellegrino et al. (2015)	Window orientation, external obstructions, dimensions, area of windows, depth of rooms, curtains and blinds, reflectance properties and external view.
Wang, Zamri (2013)	Thermal and acoustic comfort, indoor air quality, room layout, lighting
Karima, Altan (2016)	lighting systems, heating, air conditioning, natural lighting, security systems
Ali et al. (2016)	Surface temperature, relative humidity, light intensity, internal concentration of CO2
Khalil et al. (2011)	Visual and thermal comfort, ventilation
El Darwish, El-Gendy (2018)	Air temperature, relative humidity, radiant temperature, air speed
Ropi, Tabassi (2014)	Condition analysis of bathrooms, ceilings, doors, structures, walls and roofs
Wong, Jan (2003)	Thermal, spatial, visual, acoustic comfort, indoor air quality and building integrity

4.2 Step 2

At this stage, official standards and guidelines were consulted that could help in the elaboration of a list of criteria for the evaluation of school buildings. Table 4 lists the standards and guidelines consulted.

Table 4. Standards and guidelines consulted in the identification of evaluation criteria for school buildings. Source: The authors.

National Standards	Federal government guidelines		Assessment tools for Brazilian schools
Standards of the Brazilian Association of Technical Standards (ABNT)	1	Technical Guidelines Manual - v.2: Elaboration of school building projects: early childhood education (MEC, 2017)	Scholar Census (2019)
	2	Book of Requirements and Performance Criteria for Public Education Establishments (MEC, 2014)	
	3	Technical manual of architecture and engineering Guidance for designing construction projects for Early Childhood Education Centers. (MEC, 2009)	
	4	Minimum operating standards of the elementary school: implementation manual. (MEC, 2006a)	"Prova Brasil" (2017)
	5	Basic infrastructure parameters for early childhood education institutions. Brasilia. (MEC, 2006b)	
	6	Manual for Adequacy of School Buildings - Ministry of Education MEC (2005)	

All these norms, guidelines and academic works identified in Steps 1 and 2 were submitted to content analysis and it was noticed that there is no standard to organize the identified criteria. In this way, the authors created their own structure, seeking to organize them into groups that are related to each other. 70 criteria were identified, grouped into 11 categories, as shown in Table 5. This table also presents the ABNT standards related to the criteria identified in the systematic literature review.

Table 5. Criteria, norms and guidelines for the evaluation of school buildings. Source: The authors.

Category	Nº	Criteria	Standard NBR	Federal government guidelines						Scholar Census	"Prova Brasil"
				1	2	3	4	5	6		
installations	1	Roofs	15575-5	x	x	x	x		x		x
	2	Walls	15575-4	x	x	x	x	x	x		x
	3	Sports courts		x	x		x			x	x
	4	Playgrounds	16071-2	x			x			x	
	5	Gates, railings and walls		x	x	x	x				x
	6	Unpaved areas		x							

	7	Furniture	14006	x	x	x	x	x	x			
	8	Structures	6118	x	x	x	x		x			
	9	Parking		x	x	x			x			
	10	Stairs	9077	x	x	x						
	11	Ramps	9050	x	x	x			x			
	12	Elevators	13994			x			x			
Finishes	13	Wall paintings	13245	x	x	x	x	x	x			
	14	Coatings	16919	x	x	x	x	x	x			
	15	Floors	15575-3	x	x	x	x	x	x		x	
	16	Sockets	14136	x	x	x	x		x			
	17	Metals	10283	x	x	x			x			
	18	Frames (door and windows)	10821/ 10831	x	x	x		x	x	x		x
	19	Lining	14285/ 16382	x	x	x		x		x		
Fire security	20	Crockering	15097	x	x	x			x			
	21	fire extinguishers	12693	x		x			x		x	
	22	Escape routes	9077	x	x				x			
Thermal comfort	23	Signaling	13434	x	x	x			x			
	24	Adequacy of walls	15220-2	x	x			x	x	x		
	25	Thermal insulation of the roof	15220-2	x	x	x			x	x		
	26	Ventilation openings	15575-4	x	x	x		x	x	x		x
	27	Humidity in environments		x	x	x			x			
Acoustic comfort	28	Acoustic insulation of walls	15575-4	x	x	x			x			
	29	Noise pollution	10151	x	x	x			x			
Visual comfort	30	Natural lighting	15215	x	x	x	x	x	x		x	
	31	artificial lighting	5413	x	x	x	x	x	x		x	
Infrastructure	32	water installations	5626	x	x	x	x	x	x	x	x	
	33	sewer installations	8160	x	x	x	x	x	x	x	x	
	34	rainwater system	10844	x	x	x	x	x				
	35	electrical installations	5410	x	x	x		x	x	x	x	
	36	telecommunication systems	14691	x		x			x			

Sustainability	37	energy efficiency	ISO 50001		x	x			x			
	38	environmental management systems	ISO 14001	x	x	x			x			
	39	Waste destination		x	x	x			x		x	
	40	Rain catchment management	15527	x	x				x			
Habitability	41	Ceilings height	15575	x	x	x	x			x		
	42	Tightness to sources of moisture	9575	x	x	x						
	43	signs of predation										x
	44	Pollutants in the indoor atmosphere		x	x							
	45	Suitability for people with reduced mobility	9050	x	x	x			x	x		x
	46	Environment cleanliness level		x	x	x			x	x		
	47	building aesthetics		x					x	x		
	48	school location		x	x	x			x			x
Safety (school and student)	49	Check-in and check-out of students										x
	50	Controlling the entry of strangers into the school						x		x		x
	51	Daytime surveillance						x				x
	52	Nighttime surveillance						x				x
	53	Surveillance on weekends and holidays						x				x
	54	Policing scheme to inhibit thefts, robberies and other forms of violence										

Table 6. Weighting of criteria for evaluating school buildings. Source: The authors.

Category	Nº	Criteria	Nota Delphi
installations	1	Roofs	4,0
	2	Walls	3,2
	3	Sports courts	3,0
	4	Playgrounds	2,5
	5	Gates, railings and walls	3,2
	6	Unpaved areas	1,7
	7	Furniture	3,3
	8	Structures	3,7
	9	Parking	1,0
	10	Stairs	3,0
	11	Ramps	3,5
	12	Elevators	1,8
Finishes	13	Wall paintings	2,7
	14	Coatings	3,0
	15	Floors	3,7
	16	Sockets	3,7
	17	Metals	3,0
	18	Frames (door and windows)	3,3
	19	Lining	3,3
	20	Crockering	3,0
Fire security	21	fire extinguishers	3,8
	22	Escape routes	4,0
	23	Signaling	4,0
Thermal comfort	24	Adequacy of walls	2,3
	25	Thermal insulation of the roof	3,3
	26	Ventilation openings	4,0
	27	Humidity in environments	3,3
Acoustic comfort	28	Acoustic insulation of walls	2,8
	29	Noise pollution	3,3
Visual comfort	30	Natural lighting	3,7
	31	artificial lighting	3,8
Infrastructure	32	water installations	3,2
	33	sewer installations	3,0
	34	rainwater system	2,8
	35	electrical installations	3,8
	36	telecommunication systems	2,8

Sustainability	37	energy efficiency	3,3
	38	environmental management systems	2,7
	39	Waste destination	3,8
	40	Rain catchment management	2,8
Habitability	41	Ceilings height	3,3
	42	Tightness to sources of moisture	4,0
	43	signs of predation	3,3
	44	Pollutants in the indoor atmosphere	2,7
	45	Suitability for people with reduced mobility	3,8
	46	Environment cleanliness level	3,7
	47	building aesthetics	2,7
	48	school location	2,2
Safety (school and student)	49	Check-in and check-out of students	3,8
	50	Controlling the entry of strangers into the school	4,0
	51	Daytime surveillance	2,8
	52	Nighttime surveillance	3,7
	53	Surveillance on weekends and holidays	3,3
	54	Policing scheme to inhibit thefts, robberies and other forms of violence	3,3
	55	Policing scheme to inhibit drug trafficking within the school	3,5
	56	Policing scheme to inhibit drug trafficking in the vicinity of the school	3,3
	57	Lighting outside the school	3,7
	58	Protection mechanisms for more expensive equipment	3,3
	59	Security in your surroundings	3,3
environments	60	Classrooms	4,0
	61	administrative rooms	3,0
	62	Teachers' room	3,3
	63	computer rooms	3,5
	64	laboratories	3,5
	65	Refectory	4,0
	66	DML	2,7
	67	Kitchen	3,7
	68	Terrace	3,2
	69	Library	3,2
	70	Bathrooms	4,0

Evaluating the school facilities, the elements of the buildings identified as important from consultation with specialists are: roof, structure, walls, gates, railings and walls, furniture, sports

courts, stairs and ramps, all with scores greater than 3. The other criteria, mentioned in the RSL and in the norms and guidelines consulted, were not considered by the specialists as important elements for evaluating the performance of the school building.

Regarding the category of finishes, the criteria were considered important (coatings, floors, sockets, metals, frames, ceiling and crockery), only the painting of the walls was given a score lower than 3.

The categories of “Thermal, acoustic and lighting comfort” are generally considered important criteria in evaluating the performance of the building, although the criteria for thermal and acoustic insulation of the walls receive scores below 3.

The “Fire Safety” category, an indispensable item in the Fire and Panic Prevention and Fighting System, is unanimous in terms of importance, in the opinion of experts.

Electrical and hydro-sanitary installations are the outstanding criteria in the infrastructure category. Regarding the Sustainability and Habitability categories, the criteria of "energy efficiency", "waste disposal", "ceiling height", "tightness to sources of moisture", "signs of depredation", "adequacy to people with reduced mobility (PMR)” and “level of cleanliness of the environments”.

In general, the security aspects of the facility, property and physical occupants, Category of “School and Student Safety”, despite being important in the experts' assessment, was mentioned only in the SAEB assessment. It is understood that this criterion is not related to the building structure, but to its functioning.

For the environments mentioned in the RSL studies and in the norms and guidelines, an exclusive category was assigned, since they are not criteria, but are important enough to compose the assessment of the building. The least important environment is the DML. This environment is related to the cleanliness and hygiene of the school, however, it is mentioned only in a school evaluation instrument and for the specialists, it has a score of 2.7 on a scale of 1 to 4.

5. FINAL CONSIDERATIONS

Since the school building is the main asset of the learning process and is expected to offer quality and safety environments to users, this article aimed to identify, through a literature review, government guidelines and consultation with experts, the criteria used in research to evaluate the performance of school buildings.

70 criteria were identified, which were grouped into 11 categories according to their correlations: facilities, finishes, fire safety, thermal, acoustic and visual comfort, infrastructure, sustainability, habitability, safety (of the school and the student) and environments.

It was observed with the research that the Brazilian standards and guidelines in relation to the performance and conservation of schools are very outdated, some standards are more than 20 years old, which points to a need to review these guidelines, in order to guarantee the performance of these buildings, avoiding those defects and pathological manifestations compromise the school infrastructure, especially now with the consequences of the pandemic experienced in the last two years.

Considering also that in Brazil there are no specific norms for the evaluation of school buildings, the identification and weighting of criteria that allow such evaluation, as presented in the study, is a first step and contributes to the development of techniques and evaluation methods, which later can form a performance standard for school buildings.

As a suggestion for future work, a literature review is indicated to identify evaluation methods for the criteria presented in this research.

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