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Smart School for Secondary School with Sustainable Architecture Approach in Tonekabon

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Abstract


The school environment is particularly important because most of the time students spend there falls during the most sensitive period of their personality development. Traditional schools no longer meet students' needs because their educational programs are mostly teacher-centered and do not align with students' talents, abilities, needs, and learning styles, each of which has its own rhythm. For this reason, there is a need for schools that, by having flexible curricula, the possibility of teaching with modern methods, having a wide range of educational programs and methods, and focusing on the role of the student by considering individual differences and paying more attention to their needs, interests and talents, can be effective and useful in eliminating or reducing this educational gap. Smartization of schools is the Ministry of Education's transformational strategy for developing information and communication technology as the most prominent feature of the present era. In fact, in the smartization process, the participation and interaction of school-related elements, namely parents, teachers, and students, and work efficiency in schools are expected to increase. On the other hand, due to the school building's specific potential in relation to the environmental sustainability approach, and also the climate of the northern region, due to its vast resources of renewable energy, a school design has been considered that can have the least impact on the natural environment and the least reliance on fossil fuels.


Keywords: Smart schools, Information technology, Environmental sustainability.

1 | Introduction

A smart space is self-governing, and this is not possible without computers and software. Therefore, a smart school is a school in which the implementation of all processes, including management, monitoring, control, teaching and learning, educational resources and teaching aids, evaluation and office documents, and

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communications, is designed based on information and communication technology. The main focus of the research is on improving the educational and training system. The main goal of designing a smart school is to create classrooms and other educational spaces in a responsive, sustainable, two-way dialogue with students as users or residents, through interaction with physical objects or digital elements. The school's design assumes that most spaces are dedicated to learning. Therefore, the following questions arise [1], [2]:

- I. What effect can a smart educational environment have on the learning process of students?
- II. What is the difference between a smart educational building and a traditional educational building in terms of architectural characteristics?
- III. How can a school be designed using sustainable architecture as a model that saves energy resources and protects the environment?

2 | Statement of the Research Problem

In the dictionary, the word intelligent is also associated with concepts such as intelligence, cleverness, and wisdom. A smart school is an educational organization with a physical, real existence, not a virtual one, in which students are educated in a new way. In a smart school, control and management are based on computer and network technology, most of its courses are delivered electronically, and its evaluation and monitoring system is intelligent. Education in smart schools, computers affect the way teaching and evaluation are conducted, and change the curriculum to some extent. But at the same time, the social functions of schools still exist, because they can help students in social relationships.

In smart schools, students learn to process a lot of information and use this information for further learning. Traditional schools no longer meet students' needs because their educational programs are mostly teacher-centered and do not align with students' talents, abilities, needs, and learning styles, each of whom has their own unique rhythm. For this reason, we need schools that, by having flexible curricula, the possibility of teaching with modern methods, having a wide range of educational programs and methods, and focusing on the role of the student, taking into account individual differences and paying more attention to their needs, interests, and talents, can be effective and useful in eliminating or reducing this educational gap. In fact, every student can be educated according to their talent; in other words, the education system must adapt to students' talents. This argument is not limited to age, class, or type of people; all educational facilities must be provided to all segments of society [3].

3 | The Necessity of Research

Today, due to the growth of computer technologies, the speed of information transfers and the problem of knowledge explosion, information and knowledge can be easily and quickly available to everyone and, as in the past, school is not only a framework in which students want to transfer knowledge, skills and values to students, but also economic, social, cultural frameworks and mass media play a decisive role in the formation of students' perceptions. Considering the rapid growth of educational technologies in the present era, the future information society also needs places where information technology can be used creatively to advance the teaching of various sciences.

Also, given the importance of modern education for future generations and the lack of research that yields fruitful conclusions in this field, conducting such research is important and necessary. And finally, smart school design has a profound impact on the health and well-being of students, teachers, and staff, and creating a dynamic, innovative environment enhances learning. By considering the requirements of the environmental sustainability approach at all stages of design, it increases safety and comfort [4].

The table below examines the relationship between smart style and school learning culture with the effectiveness of the smart education system.

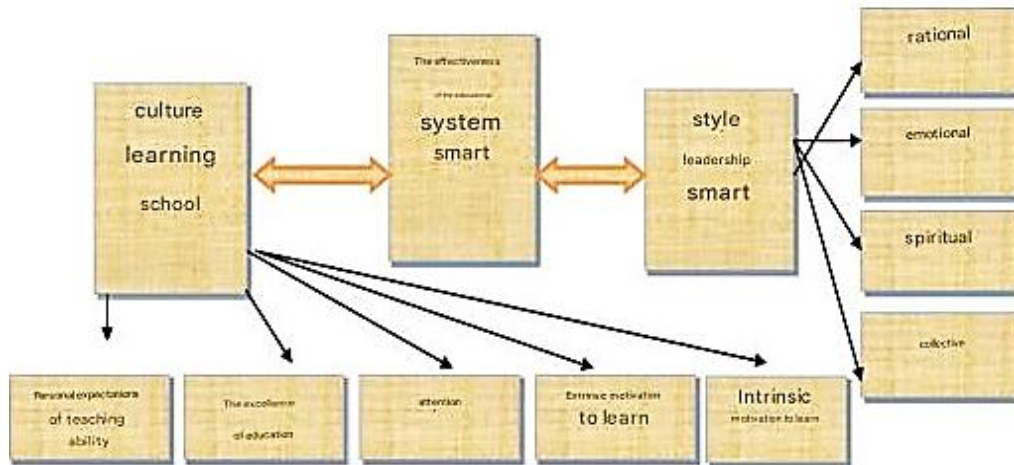


Fig. 1. The relationship between intelligent style and learning culture.

3.1 | The Novelty and Innovation Aspect of the Research

Smart school is focused on energy efficiency in Tonekabon city. All schools in this city are traditional. Smart schools are a new educational approach that will bring fundamental changes in the teaching and learning process by combining information technology and curricula. It is imagined that we will create an educational environment that fosters new development and reflects students' real experiences in their living environment. And also, instead of bags full of bulky textbooks, they will attend classes with quality computers, and even if a student cannot attend school due to illness, they can continue their studies at home. And it even seems that creating flexible spaces and educational complexes tailored to students' needs can improve the quality of their education.

3.2 | Information Collection Methods and Tools

The present research is a library and descriptive study. Drawing on written sources, relevant documents and evidence, and the intellectual foundations of experts in the fields of education and environmental sustainability, an attempt has been made to present criteria for designing these spaces.

3.3 | Definition of Smart School

A smart school is an educational organization with a physical presence, not a virtual one, where students are educated in a new way. In a smart school, control and management are based on computer and network technology, and most of its lessons are delivered electronically. Its evaluation and monitoring system is smart [5].

According to the Ministry of Education, a smart school is not a virtual school; rather, the physical connection between teachers and students is maintained in the physical space of traditional schools.

3.4 | Project Background

The higher the students' visual awareness, the better they can use their abilities, talents, and creativity. Lack of planning, lack of coherence in approaches, and forgetting values have been considered as the most important causes of the lack of proper achievement in the future in Iranian schools. If the gap between theoretical and practical education is eliminated, then solutions can be considered to deepen and improve students' education.

In general, from the second half of 2001 onwards, the approach to the smart school category became more serious and operational activities in the field of online education and the interception of telecommunication bandwidth to provide educational courses in all corners of the country began, until, according to the approvals of the information and communication technology council of the ministry of education in the academic year

2004-2005, the smart school pilot was assigned to the Tehran education organization. But similar sustainability projects in Iran have not yet been documented, and the discussion of smart education has been limited to a series of appearances, such as electric boards and several computers in schools. For the first time, in 2008, a project entitled "designing a middle school with an earthquake-resistant approach" was completed in Tehran, which focused more on the relationship between structure and architecture and less on clean energy and the conservation of natural resources.

Therefore, the purpose of this research is to use modern methods consistent with global standards in education for smart education. Students can use it according to their interests and talents, allowing us to offer a flexible educational package tailored to their needs and enhancing their education.

3.5 | A New Approach to Educational Methods and Behaviors

Traditional education tends to emphasize the curriculum. In contrast, modern education literature considers education as a combination of curriculum and teaching methods. Traditional education views the curriculum as subject matter, while the new approach sees it as providing socially valuable knowledge, skills, and attitudes. In the new education system, the role of the teacher is not limited to the curriculum; it is considered the most important part of education. In this system, the independence and freedom of the teacher and the student are considered fundamental principles of education. In this system, the teacher is expected to help students recognize and develop their talents, rather than transfer information and knowledge. In the table below, we examine two traditional and modern perspectives on education [6].

Table 1. Comparison of traditional and modern perspectives on education [7].

Traditional View	Modern Perspective
The student's passive role	Active role of the student
The teacher as a distributor of knowledge	The teacher as a guide in the educational experience
The teacher is an educator and a coach	A teacher is a facilitator
Learning is a one-way process.	Learning is continuous and flows in both directions.
Reliance on memory	Relying on discovery and investigation
The teacher is responsible for learning.	The student is responsible for learning.
Emphasis on information	Emphasis on investigation
Emphasis on encouragement and punishment	Emphasis on intrinsic motivation
Emphasis on competition	Emphasis on collaboration
Results are important	How to proceed is important (emphasis on process)

3.6 | Goals of Making Schools Smart

Goals are the expected objectives over long periods of time. The goals of smart schools are defined in a way that aligns with the organization's goals and paves the way to achieving them. The goals of smart schools are also formulated in line with the vision to make it possible to achieve the vision with these goals. The organization's goals have defined and approved its macro-directions. These macro-directions are considered the basis for aligning the goals of smart schools with the organization.

In *Fig. 2*, we examine the goals of smartization.

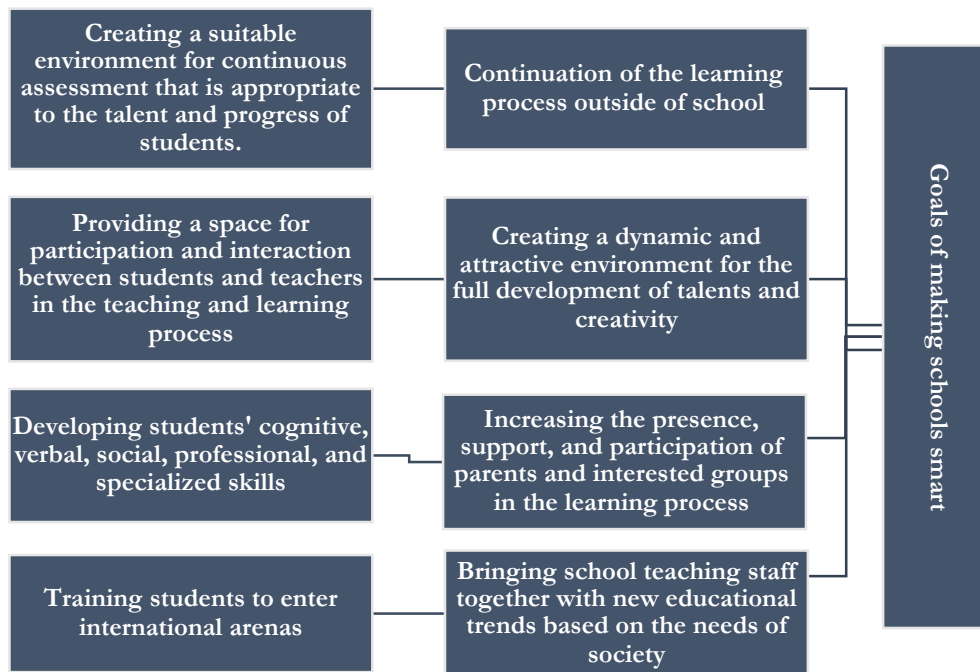


Fig. 2. Goals of smart schools aligned with organizational macro-directions.

Given the goals of a smart school and its orientation to educating students, it requires equipment and facilities that traditional schools do not. This equipment includes the following:

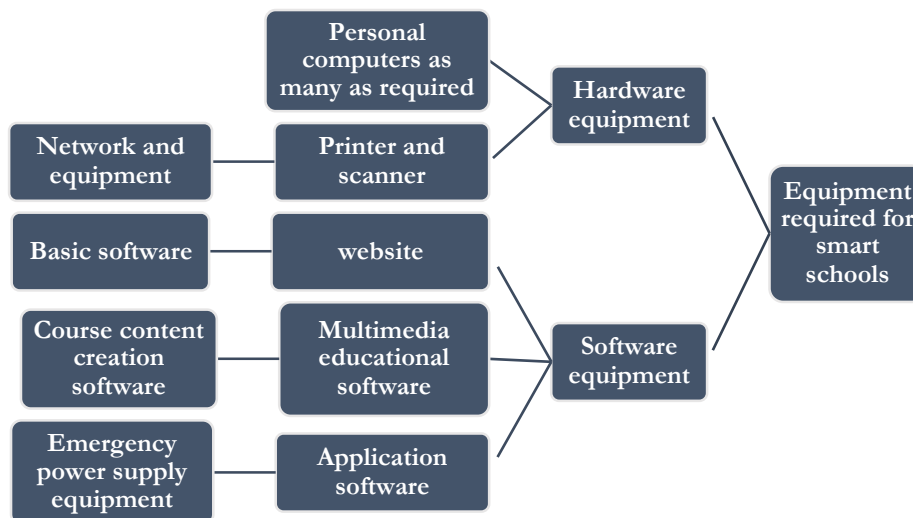


Fig. 3. Required equipment and facilities for smart schools.

3.7 | Smart School Technology

The policies governing the smart school include its legislative policies and regulations, as well as its effective functioning, so that the operational process, as outlined in the table below, is carried out successfully.

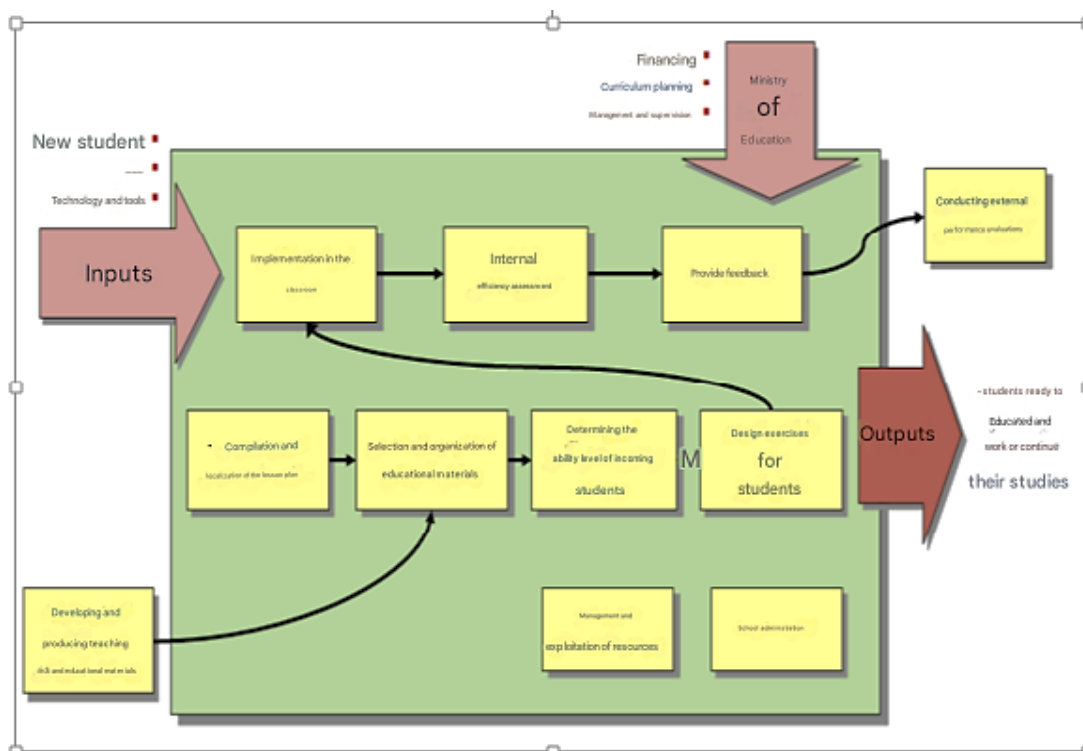


Fig. 4. The policy governing the smart school (URL1/20).

4 | Smart School Conceptual Model

To establish a smart school, a model must be presented that identifies the components of this type of school, serves as a reference for the development of smart schools, and distinguishes it from non-smart schools. According to studies, the conceptual model of the smart school comprises five main elements. This model is shown in the figure below.

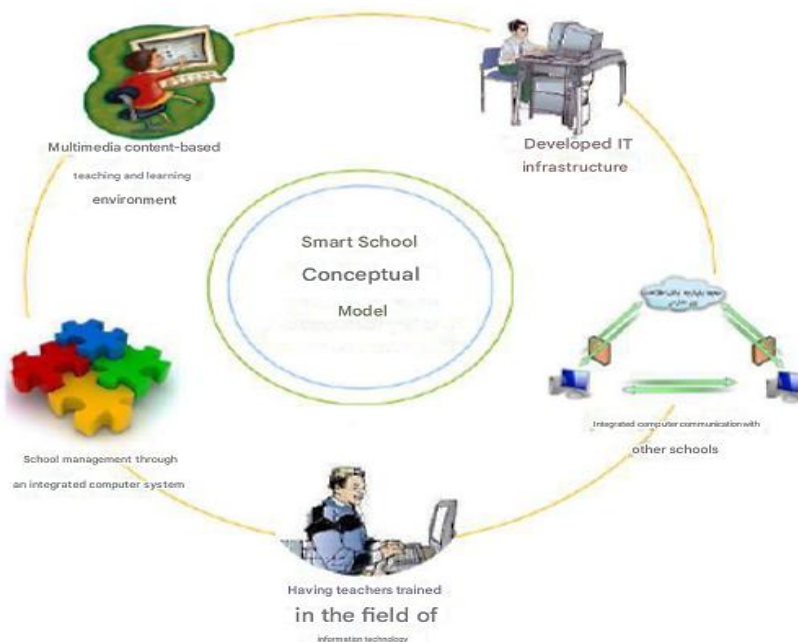


Fig. 5. Smart school conceptual model (education organization).

4.1 | Main Components and Pillars of Making Schools Smart

In smart schools, teachers learn alongside students, instead of being the sole speaker in education, and play a facilitating role in students' self-directed learning, and students, with the guidance of the teacher, shape their own goals. For example, the student selects the resources he wants and asks the teacher for their opinion. And because the smart school is an electronic content, in a general definition, it is an effective tool for education that provides a communication platform between students and teachers anywhere in the world with a combination of text, image, sound, and video, in a way that can create an innovative and creative education for education researchers and students. Likewise, the presence, participation, and full support of parents and society in the teaching and learning process and in guiding students will be clearly visible and at a high level. Finally, smartization in our country, with a significant difference compared to other countries, will make sense to the audience by equipping classrooms with computers, projectors, and smart boards, and using specialized educational software. The diagram below shows the main components of school smartization [2].

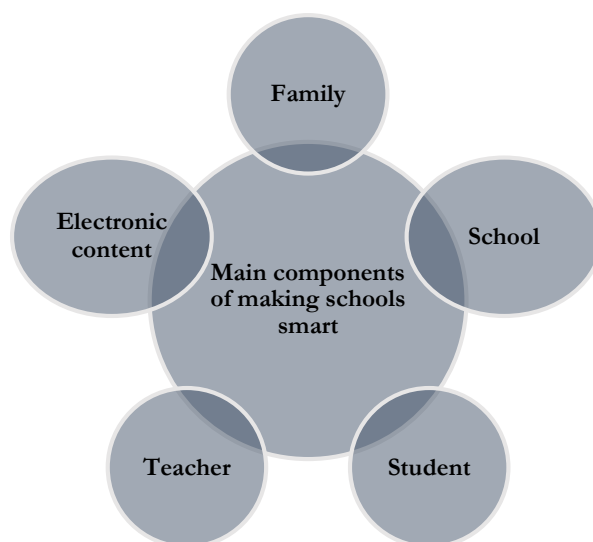


Fig. 6. Main components of school smartization and stakeholder roles.

4.1.1 | Main axes of smart school design

A smart school should have easy access and public transportation for students and teachers. And there should be a clear identity of a school, for example, a building should be in line with the goals of education. The school should provide students with a sense of security, comfort, and convenience. Because the school is smart, software and hardware equipment should be available to students. Although a good teacher can be effective even in inappropriate conditions, if the space and educational equipment are suitable, the quality of teaching will improve. The table below categorizes the important axes for a smart school [8].

Table 2. Key dimensions and infrastructure requirements of a smart school.

Axes	Micro-Options
School location feature	Ease of access for students and teachers to the school building Ease of access to public transportation Ease of access to municipal services
School safety and health	No use of hazardous materials in school Existence of a fire alarm, notification, and response system Existence of a system for detecting and responding to floods, earthquakes, and bad weather conditions Existence of health services and treatment facilities Existence of facilities related to emergencies (such as escape stairs)

Table 2. Continued.

Axes	Micro-Options
School identity	Suitability of the building for the goals of education Ease of distinguishing the school building from other buildings Beauty of the interior environment Use of smart glass and smart materials in the facade
Comfort at school	The presence of lighting control systems, ambient temperature control, and air pressure control provides fresh air and a pleasant smell. Creating sufficient space for each student in the school The ability for students to control some activities in the classroom Ease of access for students to classes The presence of voice command receiving systems The presence of emergency power systems
The importance of school	The presence of manual control systems and intelligent traffic The presence of visual surveillance inside the school (CCTV) cameras The presence of information security systems and communication networks
School communication systems	The presence of computer networks in the school (internet) The possibility of students connecting to the internet The presence of video conferencing systems The presence of smart bulletin boards in the school
Service and support of the smart systems used	Availability of continuous and appropriate system services Ability and ease of system maintenance Savings in system maintenance and support costs







Architectural documents and pictures	Project title
	<p>Rosa Parks School</p> <p>Location and specifications:</p> <p>United States of America, Portland Oregon.</p> <p>Dal Elson Weeks Architects Group.</p>
	<p>Phelps Academy Center Phillips Academy Exeter</p> <p>Location and specifications:</p> <p>United States of America, New Hampshire Exeter.</p> <p>Center Brook Architects and Planners</p>
	<p>Lake Wilmerding High School</p> <p>Location and specifications:</p> <p>United States, California, San Francisco</p>
	<p>Holton Richmond High School.</p> <p>United States, California, San Francisco</p>

Fig. 7. Perspectives of leading architects on sustainable architecture and design [9].

4.1.2 | Sustainable architecture

Ken Young, Richard Rogers, Norman Foster, Thomas Herzog, and Jan Kaplicki are among the famous architects in sustainable architecture, designing and implementing projects. Ken Young: sustainable design is ecological design. In fact, sustainable design is a type of design that is in complete harmony with the earth's ecological systems throughout its life cycle. Richard Rogers: sustainable design is a type of sustainability that aims to respond without harming the resources of future generations. Norman Foster: sustainable design means the optimal use of architectural tools to save energy rather than relying on wasteful mechanical systems that run on non-renewable fossil fuels.

4.1.3 | Principles of sustainable school design

To implement sustainable design principles, it is necessary to integrate these concepts with a school's needs, resulting in a set of principles for creating a valuable architectural space. The principles that must be followed for a building to be classified as a sustainable building are as follows:

Table 3. Principles for classifying buildings as sustainable [10].

Energy conservation: the building should be built in a way that minimizes the building's need for fossil fuels.
Climate compatibility: the building should be designed to work in harmony with the climate and energy resources available at the construction site.
Reducing the use of new resources: buildings should be designed in a way that reduces the use of new resources as much as possible and, at the end of their useful life, can be used as a new resource for the construction of a new building.
Meeting the needs of residents: in sustainable architecture, meeting the spiritual and physical needs of residents is of particular importance.
Site compatibility: the building should be gently placed on the ground of its site and be in harmony with the surrounding environment.
Holism: all the principles of sustainable architecture should be embodied in a complete process that leads to the creation of a healthy environment.

4.1.4 | Characteristics of sustainable schools

Sustainable development encompasses three important dimensions:

- I. Environmental sustainability, which includes the use of renewable energy, the conservation of natural resources, and the effective protection of the environment.
- II. Economic sustainability.
- III. Social sustainability.

In general, the effort is to provide solutions that achieve environmental, social, and economic objectives of better quality for current and future generations. The following table categorizes the types and characteristics of sustainable schools.

Table 4. Types and characteristics of sustainable schools [11].

Sustainable school roofs	Flat roof with central open space, glass corridor, and classroom with a light roof
	Pitched roof with glass surrounding space or solar space, sometimes with a central corridor
	Wave or stepped roofs to provide cross ventilation at different levels with the help of the sun
Energy in sustainable schools	<p>The more we reduce energy costs, the more we can spend it on education.</p> <p>Implementing saving guidelines is a practical lesson for students that stays in their minds and spreads in society.</p> <p>The factor is related to the comfort conditions in this space, because the more comfortable the conditions are in the education space, the higher the quality of education.</p>
Central spaces in sustainable schools	Central spaces, glass corridors, and greenhouse spaces are common features of sustainable school design. They provide a suitable, environmentally friendly classroom space. For example, students spend their leisure time in these spaces under their teacher's supervision.
Classes in sustainable schools	Adequate door and window control between teaching and learning spaces
	Acoustic protection of the classroom against internal and external noise pollution
	Identification of solar spaces that can reduce light and ventilation of learning spaces.
	Design of a responsive system for solar shading to prevent excessive heating in summer
Classes in sustainable schools	Adequate door and window control between teaching and learning spaces
	Acoustic protection of the classroom against internal and external noise pollution
	Identification of solar spaces that can reduce light and ventilation of learning spaces.
	Design of a responsive system for solar shading to prevent excessive heating in summer
	Use of a type of joinery that allows maximum sunlight to pass through.
	Ventilation that is enhanced by the sun, with wind, and through upper and lower windows, and perhaps the sloping roof of the classrooms.

4.1.5 | Characteristics of different types of sustainable school plans

There are usually 5 main types of plans accepted for schools. The table below shows the types of plans and the characteristics of sustainable school plans.

Table 5. Types of school plans and features of sustainable layouts [11].

Energy Consumption	Disadvantages of the Plan	Advantage of the Plan	Plan Layout	Types of Sustainable School Plans
Relatively efficient	Mechanical ventilation and cooling	Use of ceiling lighting and ventilation	A square with classrooms on two or three sides and a lobby, office, and library on the other sides.	Compact plan
Relatively efficient	The ratio of the height to the perimeter of the walls of the sections and the volume of the interior space increases construction costs.	View from the central corridor to both the yard and the classrooms (allowing teachers to monitor).	Similar to compact plans + an uncovered open space in the middle	Yard plan
Relatively efficient	Protecting the school from adverse climatic conditions by extending the wings and creating shelter-like spaces between the classrooms.	Wings have climatic and environmental benefits.	Classrooms along off-center axes of the public space	Radial plan
Efficient		South facing skylight - allowing deep daylight penetration into the interior ventilation plan without the need for mechanical systems support	Classrooms are usually separated by a rear corridor or glass passageway on the south facade, consistent with classrooms on the north side.	Linear plan
Inefficient		Direct response to the natural features of the site	As a link between the rest of the plans	Organic plans

5 | Conclusion

Due to the shift from traditional to smart schools, there have been changes in school architecture and educational needs. Also, the necessary conditions and skills for students must be strengthened so that they can make optimal use of the new and innovative environment.

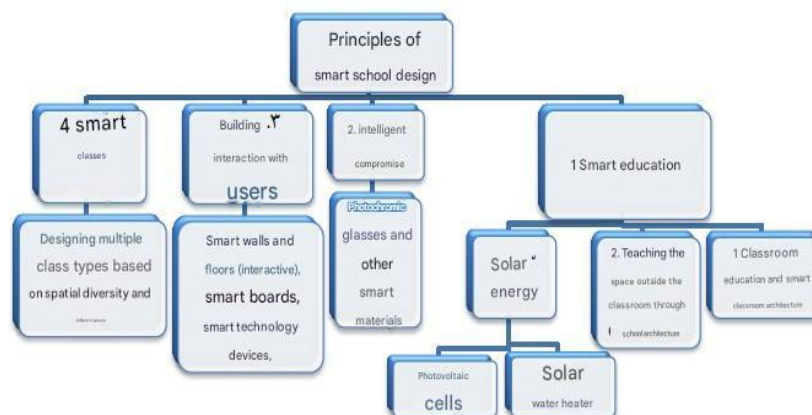


Fig. 7. Key design factors for creating an integrated smart educational environment.

The most important factors in designing smart schools are education, smart materials, the appropriateness

and applicability of spaces, and smart classes aligned with students' interests and talents. Since the school's structure is smart, classes must be connected to smart technology software and devices, and the interior should feature modern materials such as smart glass and other smart materials. To preserve the environment, save energy, and use renewable materials, solar panels, solar water heaters, and photovoltaic cells should be used. As a result, it can be said that a smart educational environment is not a building that uses only the latest educational technologies; rather, it should be created by integrating several factors, such as smart materials and beautiful, attractive interior design, alongside educational technologies.

Authors' Contributions

The author solely conducted the research and prepared the manuscript and has approved its final version.

Data Availability

The data are available from the corresponding author upon reasonable request.

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Conflict of Interest

There are no competing interests to declare.

Consent for Publication

The author confirms consent for the publication of this work

Ethics Approval and Consent to Participate

This article does not include experiments involving humans or animals.

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