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SMART MATERIALS AND IOT ADAPTABILITY IN ARCHITECTURE AS TRANSFORMATIVE ELEMENTS IN THE CONCEPT OF CREATIVE CHILDREN SPACES

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ABSTRACT

As a result of the development of materials, can be employed in the creation of spaces and forms within the buildings more interesting and remarkable, converting materials that meet environmental and structural function to more benefit from the distinctive materials in buildings used for children, especially those buildings that contribute to the output of positive energy in the form of indirect education - where Modern educational approaches are aimed - at creating a creative and innovative generation. The creative environment for children is the environment that contributes to raising the child's imagination and expectations according to elements that help in using them in an unusual way.Here, the creative child possesses unlimited imagination and architecture must respond to those needs for stimulating imagination with what smart materials can offer. Smart materials are more multifunctional "changeability and responsiveness according to needs". Being flexible and adaptable to the environment by improving building's impact to provide healthier and more efficient environment.The research aims to utilize concepts of smart materials and intelligence techniques that act more dynamically. IoT Internet of things emerged the architecture spaces giving more smart potentials.

The application of "Internet of Things" in the architectural spaces affects the built environment. The research question is whether the use of smart materials and IoT technology in children's spaces provides a creative an innovative environment?

The dramatic increase in technology with new systems has encouraged the study of the different characteristics of building materials. Through the analysis of some case studies that deal with children's spaces, there is a presence of the characteristics and practices of intelligence in architecture.The findings confirm that the use of smart materials and new technological techniques in children's spaces is the source of the positive benefits that create a cognitive relationship between the child and his environment.Through the lessons learned from the analytical study, some ideas were proposed to enhance the concept of creativity in architecture while giving a new dimension to the space and time.

KEYWORDS: Smart materials , IoT, Creativity, Children Spaces ,Built Environment

المواد الذكية وتوظيف تقنية "انترنت الأشياء" كعناصر تغيير في مفهوم فراغات الإبداع للأطفال

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الملخص

نتيجة تطور المواد أمكن توظيفها في إيجاد حيزات و إشكال ضمن المباني أكثر تشويقا وتحويلها من مواد تلبي وظيفة بيئية وإنشائية إلي الاستفادة منها في مواد نجدها أكثر تميزا استخدامها في المباني المخصصة للأطفال وبالأخص تلك المباني التي تساهم في إخراج الطاقة الايجابية في صورة تعليمية غير مباشرة وهو ما يتجه إليه المناهج التربوية الحديثة في خلق

جيل مبدع ومبتكر. البيئة الإبداعية للأطفال هي تلك البيئة التي تسهم في إثارة خيال وتطلعات الطفل وفق عناصر مساعدة في استخدامها في صورة غير المعتاد عليها والطفل المبدع من يمتلك خيال بلا حدود ويجب ان يتم الرد علي ذلك الخيال بتصرفات بخامات تلبي ذلك الاحتياج وهو ما يتوفر في مواد البناء الذكية. إن تقنيات المواد الذكية لها القدرة علي التكيف الملحوظ يظهر دورا مهما في تطوير تكنولوجيا البناء. أصبحت المواد متعددة الوظائف لها خصائص أهمها" قابلية التغيير والتجاوب وفقا للاحتياجات". توفر النظم الذكية المرونة وقابلية المبني للتكيف مع بيئته من خلال تحسين تأثير المبني لتوفير بيئة أكثر صحة وكفاءة اعلي للمبني. يهدف البحث إلي استخدام مفاهيم التطور في المواد الذكية وتقنيات الذكاء التي تؤدي وتتصرف بشكل أكثر ديناميكية. اثر دخول تقنية " انترنت الأشياء" في مجال الهندسة المعمارية مما أعطي فراغات وإمكانات أكثر ذكاء. إن تطبيق "انترنت الأشياء" في الفراغات المعمارية يؤثر علي البيئة المبنية. يكمن السؤال البحثي بان هل استخدام المواد الذكية وتقنيات "انترنت الأشياء" في فراغات الأطفال يوفر بيئة إبداعية؟
أدت الزيادة الهائلة في التكنولوجيا مع نظم الإنشاء الجديدة إلي التشجيع علي دراسة الخصائص المختلفة لمواد البناء.
من خلال تحليل بعض النماذج من دراسات الحالة التي تتناول فراغات الأطفال تبين وجود مميزات وممارسات الذكاء في العمارة. تؤكد النتائج إن استخدام المواد الذكية والتقنيات التكنولوجية الجديدة في فراغات الطفل هي مصدر الفوائد الايجابية التي تحقق علاقة معرفية بين الطفل وبيئته. من خلال الدروس المستفادة من الدراسة التحليلية تم اقتراح بعض الأفكار من اجل تعزيز مفهوم الإبداع في العمارة مع إعطاء بعد جديد للزمان وادراك المكان.
الكلمات المفتاحية: المواد الذكية - انترنت الأشياء – الإبداع – فراغات الأطفال – البيئة المبنية.

1- INTRODUCTION

Smart materials appearance in architecture is of great significance to meet needs and requirements of the 21st century. It inspires architects to provide better conditions for occupants. (Nasr, 2017)

New materials are being developed for advanced solutions to long-term problems. Exploring these technologies leads to discovering new materials considered as a multipurpose material; for creative architecture solutions. (Mohamed, 2017)

This research focuses on the incorporation of smart materials technologies in architecture engineering expound its prospective to create a vast influence on architectural creating new dimensions to form and space in children's buildings fostering creativity and imagination.

1-1 Research Objectives

Study the influence of Smart materials and potentials of nanotechnology on architecture to investigate its role and function as a flexible approach in architecture application. Introduce the emergence of the Internet of Things (IoT) concept in Architecture. Show and propose how smart materials and its Innovative technologies application can be applied in children spaces as an approach for a creative environment.

1-2 Research methodology

The research follows theoretical descriptive, analytical method. The Theoretical Descriptive part is to: investigate design considerations for children for creative environments, discover various aspects of technologies include smart materials classification and fundamentals and advantages, study emergence of Internet of Things (IoT), explore their effect on Architectural form elements, function and spaces of children.

The analytical study is to: analyze two case studies, summarizing results of comparison, followed by proposed ideas to consider implementation of technology in children Architectural spaces.

2-Shaping the future: Designing for children

Space and the child relationship is of great importance, that support the child to grasp the utmost compatibility of necessities of the activity practiced within these spaces.

Technology has influenced the child's human needs and design his architectural space.

Smart Architecture techniques in designing internal spaces to provide and respond to children needs applying concepts of interaction and integration in spaces to stimulate creativity. (Dobbins, 2018)

Advances of the architectural spaces and the emergence of information technology, reflected on changing child space and the indications of his growth. Technological considerations have an huge impact on the child's developmental features and human needs. Information technology is one of the hierarchical levels of the child's human needs. Fig. (1)

Fig (1) Information technology is one of the hierarchical levels of the child's needs. ((Desouky et Al., 2016)

Where the information technology aid in the improvement of design solutions to spaces creating more flexible, adaptable and ease the movement of the child within.

2-1-Design consideration for Children:

Some Architectural major bodies push for localized standards, those targeting to encourage a safe and healthy learning circumstances, architects should think of spaces to support self-learning, promote play, creating the right level of social interaction between ages.

2-2 Creative environment for children:

It is the environment in the child grows and develops. The environment either stimulates creativity, supports it, or undermines and impedes.

With the speed of progress in this era and the involvedness of the technology fields in the information age the need to address creativity is increasing. To develop the creative abilities of the child, he should be exposed to many of the real experiences that contribute to the expansion of innovations, and encourage the continuation, and the positive outlook.

The built environment has a great influence on the creative process, which provides an atmosphere and conditions appropriate to support the creative energies and promote a culture of creativity and innovation. Creativity does not happen randomly but is enhanced by environmental factors.

2-3 Child centric design: (Dobbins, 2018)

safety	safety is crucial for children, referring to soft edges/ soft materials in soft designs.
play	spaces that permit the needed natural creativity and independence of play, and cherish it, by creating an adaptable, a multi-use space.
Liberation	Facilitating children to intermingle or navigate within the spaces, letting the children be free and self assisted within the design, children can interact with the space.
Adaptability/ Openness	flexible adapted spaces to any situation, open, and accessed to nature.
Understanding	create specialized spaces for children that foster their freedom and creativity

3- SMART MATERIALS

The role of materials has transformed from their pre-modern role of being secondary to architectural needs where new formal responses and functional implementation increased. Materials of Façade disconnected from the building's structure and infrastructure, led to freeing the material choice. The interior and exterior Buildings' materials developed to be part of a design. Smart materials will reshape building surfaces, walls and facades, enhancing their design from a static to an interactive. (Addington et Al., 2005)

Smart materials defined as "highly engineered materials that respond intelligently to their environment" (Addington et Al., 2005) They can achieve sensing and actuating functions, upon the applying of an external stimulus (form of light, sound, temperature, electric field,

magnetic field and stress). Their properties are changeable and therefore response to transient needs. Smart materials can be classified into two types. (Makakli, 2017) (Table (1) illustrated the two types of smart materials classification):

Table (1) describes classification of smart materials(Author adapted from: (Addington et al., 2005)

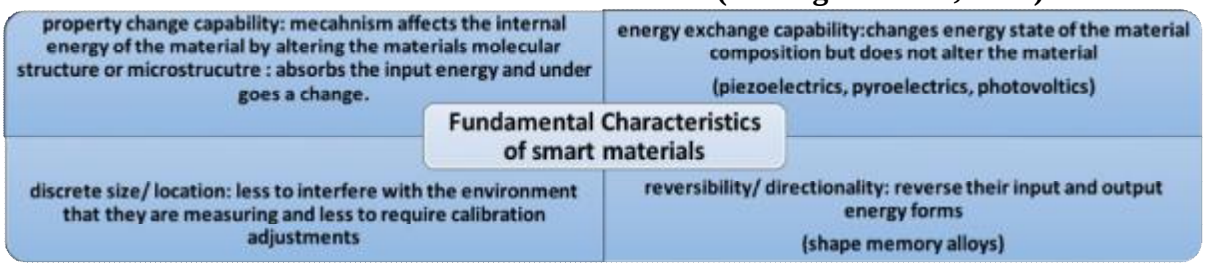
Type 1 smart materials property changing - Chromic or color changing smart materials		
characteristics	Photochromics	-Materials that can change color upon exposed to light
change their optical properties under different external stimuli (e.g. heat, light or a chemical environment) which often perceived as a color change.	Thermochromics	- Materials can change color due to changes in temperature - Have reversible changes
	Mechanochromics	- Materials can change color due to imposed stresses and / or deformations
	Chemochromics	- Materials can change color when exposed to chemical environments
	Elctrochromics	- A reversible color change of a material caused by application of an electric current.
	Phase – changing materials	-Many materials can exist in several different physical states- gas, liquid or solid. Known as phases.
	Conducting polymers	-Change their electrical conductivity in response to a change in the strength of an electric field applied to the material.
	Rheological property-changing materials	- Properties of flowing matter: fluids and viscous materials - change their properties in response to electric or magnetic field
	Liquid crystal technologies	- An intermediate phase between crystalline solids and isotropic liquids, Sensitive to electrical fields, applicable for optical displays
	Suspended particle displays	- Activated electrically, able to change from an opaque to a clear color instantly and vice-versa.
	Other type 1 materials	- Shape- changing gels or crystals, can absorb huge amounts of water and when drying out, can revert to their original sizes
Type 2 Smart materials – energy-exchanging: Energy fields- environments – surround all materials		
characteristics	Light – emitting materials	
When the energy state of a given material is equivalent to the energy state of its surrounding environment, then the material is in equilibrium.	Luminescene	- The emission of light due to incident energy, Light caused by the re-emission of energy in wavelengths in the visible spectrum
	Chemoluminescence	- Produces light without a corresponding heat output.
	Electroluminescence, Fluorescence, phosphorescence	- The voltage provides the energy required, Widely used for light strips
	Basic semiconductor phenomena	- Such as silicon neither good conductor nor good insulators - Exhibit good properties when surrounding temperatures are varied
	Photovoltaics, leds, transistors, thermoelectrics	- phototransistors convert radiant energy from light into a current. - Common LED based on the converse of photovoltaic effects.
	Piezoelectric effects and materials	- mechanical force applied can produce a deformation produces an electric voltage
	Shape memory alloys	- to revert or remember or previously memorized or preset shape.
	Shape memory polymers	- Polymers can be easily fabricated in a number of different forms.

Fig (2)DSSC building-integrated photovoltaic, Geneva

3-1 Conceptual Characteristics of smart materials and systems (Addington et Al., 2005)

- Immediacy: respond in real time
- transiency:respond to more than one environmental state
- self-actuation: intelligence is internal to rather than external to the material
- selectivity: their response is discrete and predictable
- directness: the response is local to the activating event

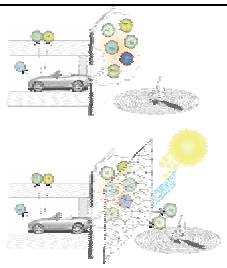
3-2 Fundamental characteristics of Smart Materials (Addington et Al., 2005)



3-3 Impact of Nanotechnology in developing building materials:

Nanotechnology has the ability of generating new materials, tools, and systems by captivating the molecular levels consuming properties that arise in those levels. (Gharabaaghi et Al., 2014). It includes materials science and many other scientific areas. (Makakli, 2017) It has influenced building methods and facades design, led to the production of building materials with new functional, aesthetical and environmental properties. Table (2) effect of nanotechnology on materials.

Table (2) Applications of nanotechnology (Aysin et AL., 2014)

1-Structural Materials	Concrete/ steel / wood	improve structural materials by reinforcing existing materials with the addition of nanoparticles in order to develop the properties, providing the structure constructed by new materials. Fig. (3)application of transparent concrete	 Fig.(3) Shanghai Pavilion 2010
2-Non Structural Materials	Glass/ plastics	helps improve the properties of glazing especially the heat gain and loss by thin-film coatings.	
3-Nanomaterials for Insulation	Nano coatings, aerogel	insulation materials and applications will be more efficient and less reliant on non renewable resources.	
4-Coatings	Self-Cleaning, scratch-resistance/ Anti-fogging, antimicrobial. Fig. (3)		Fig (4)Torres de Especialidades, Mexico City, neutralize air pollutants- absorbs toxins coated with titanium dioxide.
5-Solar Energy Applications and Energy Storage	Utilizing solar energy as a renewable source is one of the main approaches to achieve a sustainable building.		
6-Nano Sensors	Monitoring the environmental conditions and controlling the material and component performance in contemporary structures.		fig (5) Monte verde building, adhesion changing smart materials coated with a film of titanium dioxide
7-Adhesives	Gecko-inspired adhesive	Adopting principles and mechanisms are found in nature.	

3-4 Advantages of smart materials: (Roy, 2016)
• Cost Effective • High strength, toughness. • Increased durability. • High resistance to chemical corrosion, abrasion. • Easy Manufacturing and installation procedures.

Architecture is described as responsive, dynamic or interactive with emergence and wide spread of new materials, technologies and electronic computer systems.

4- IoT: Revisiting the design context

The term Internet of things (IoT) was first generated by Kevin Ashton in late 90s, approached widely in different domains by the progress of technologies of communication and mainly wireless communications. (Sun et al., 2018) Internet of things is a network, embedded with software, electronics, sensors, actuators and network connectivity, that allows connection and exchanging of data between these objects. IoT connects everything. (Yogi et Al., 2018) allowing an object to communicate, converts the devices from being smart by communication and computer embedded applications to revolutionize human experience.

IoT can be defined as "a set of technologies for retrieving the data gathered by numerous devices throughout wireless networks" (Park et Al., 2018) They are transforming ways people live. Internet can be in Everything, redefining the way people interact with each other and objects they are surrounded by. (Sun et al., 2018) Changing every feature of the building – how we inhabit, manage and build them. Fig (6) illustrates application of IoT

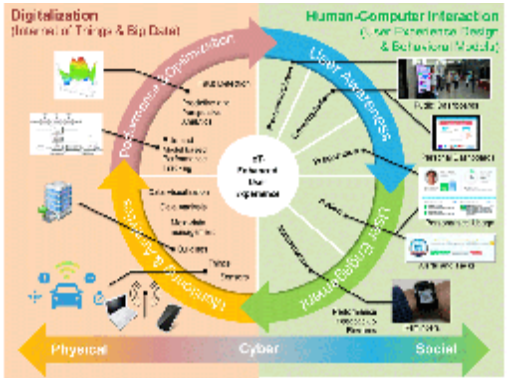


Fig. (6) IoT applications

5-Digital Technology gives new dimension for time and space:

The information revolution - as digital technology- altered the objectives of thinking and creative architecture, removing the borders amongst the material and the information, the truth and imagination, organic and inorganic. (Rafaat, 2007) There is a new time and space relationship that forms the city. The spatial description is no longer static but moves towards post-imaging programs separated by data exchange.

Smart materials and IoT gave new potentials in Architecture perception.

5-1 Multimedia architecture:

Media intervened in the architectural language by changing its outer face. The electronic media had a huge influence on the formation of the urban space in the aesthetic language that spread in the neon and laser advertising boards with photos and facades. The walls turn into information carriers. **(Rafaat, 2007)**

Fig (7) Multimedia façade – Parinee Tower – Mumbai – India- Arup – the building façade integrated with LED screens and various lighting features for multimedia displays

Fig. (8) Media Architecture - Zhuhai Opera House in Zhuhai, China, two shell, new urban perceptions, color the city, dynamic lighting creative passage, create a common platform for play.

5-2 Interaction Design:
Interaction is the communication between the user and the computer, whether direct or indirect. With the growth of different cultures, human behavior has been persuaded by technological progress، the appearance of Internet networks, the designer supports the spirit of interaction makes designs often require contribution and interaction between individuals.

Interactive Architecture design commands the study of the users' necessities and behaviors inside the place. Interactive Interior spaces integrate the physical dimensions of the space and the electronic dimensions are integrated without canceling each other. The interaction between the dimensions of the structure of the space, which is divided into:
Multimedia Architecture is considered an attract to create a new art characterized by the interactive aspect, both physical and mental activity, the digital revolution and the emergence of the computer helped in enriching and implementing the effectiveness larger and more accessible. Many styles enhance the artistic aesthetic aspects, and can develop the cultural, behavioral and entertainment aspects.

Contemporary boundary
Boundary definition is a real or notional line specifying the boundaries of an area. Therefore, the boundary is static and can be described and its limit for marking prescribes that is tangible and can be a visual piece.

Implementing smart materials in architectural design maintains the vocabulary of the two dimensional surface. The spatial envelope behaves like a boundary. (Addington et Al., 2005)

Responsive elements are critical to explore the aesthetic expression as a technical solution and can present new architectural features in building, introducing dynamic qualities. A building can have multiple configurations, according to time of the day, the season and the use. (Ellika et Al., 2019)

6- Technological development and its impact in re/designing the architectural space of the child: (Desouky et Al., 2016)

Components of the architectural space:	space limits and traditional structural elements	to flow and interactive dynamics and movement determinates. became more flexible spaces, developed to provide galleries for activities to gather children to interact positively among them
Special criteria for the visual vision of the space:	criteria (scale and proportions, balance, and the system of elements, shape and fixed configuration)	to the composition of communication units and spatial elements and flexibility of its formation. became easy to develop to accommodate the various technological tools to develop the child's mental abilities, sensory and promote his intelligence.
Criteria for the quality of the space:	(color, lighting, acoustics, texture, ventilation)	has become an interaction between the space and the surrounding environment the use of smart building materials, and the adoption of its characteristics on the Architectural form. spaces embedded with electronic systems and modern technological methods, and there are adaptations for ventilation and lighting to suit the child.

6-1 Design dimensions affecting the architectural spaces of children: (Desouky et Al., 2016)

- Form:	**- The human dimension:**	**- Environmental dimension:**	**- Physical dimension:**
- Separation of free and dynamic external configuration of the internal space, and the transformation of the exterior space - Convert some spaces into spaces with open ceilings, while the facades are connected in one composition. - Non-compliance, flexibility and changeability.	- The space has become a median for the transfer of information. - Helped to save time and effort -Achieving communication between family members and children no matter how far away - Transform elements built into smart elements - Development of the sensory dimension of the child and raise the level of intelligence	- Develop the design process with programs compatible of the building with the surrounding environment - The use of natural and artificial lighting analysis systems to determine their impact on the user and find solutions - Achieving thermal comfort for users - help building to make it sustainable and healthy for the child	- Develop of use of smart materials - The emergence of smart materials integrated with control systems and communications. - The interaction of the child with nature and the surrounding environment adapting to changes, and development of his sensing to the surrounding environments. - Link building with smart systems, control and provide safety of the child.

6-2 Smart Applications in Children spaces:

1- Study spaces	Tilt and touch table: Interactive education	 
2- Interactive play	Interactive floor:	 
3- Museums	Interactive spaces/ virtual reality/ Internet of things	 fig (9) examples of smart applications in Architecture.
4-Open spaces	Interactive/ smart spaces	

7- APPLICATION STUDY:

In this part, the researcher chooses museums as one of smart applications in children spaces. Two case studies will be analyzed depending on the theoretical part illustrated in terms of the impact of technological development on the architectural space of the child and the design dimension affecting the child spaces.

Two museums have been chosen including different activities for children, the first case study

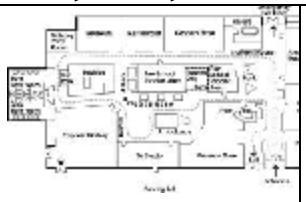
is the children's museum of Houston in USA representing the standard recognized design of museums and the second case study is Digital Art Museum by which it will illustrate the alteration in visualizing the space and correlating the digital technology in creating different environment.

Process of Analytical study:

1- Description of case studies and the different activities/ spaces provided in each.
2- Analysis of each case study based on the design dimensions (form, human, environmental and physical dimension) in terms of (Components of the architectural space, criteria for the visual vision of the space, criteria for the quality of the space)
3- Summary of the analysis in a matrix comparing results to show transformation in several aspects of application of technology in architecture form and space.

7-1- Children's Museum of Houstan, USA

Table (4)

<table>
<tr><th colspan="3">Children's Museum of Houstan, Texas, USA</th></tr>
<tr><td rowspan="5">Description/ philosophy</td><td>  </td><td>  </td><td>  </td></tr>
<tr><td colspan="3">Fig (10)exterior form of the Children Museum in Houstan- (Middle – Plan of museum)</td></tr>
<tr><td colspan="3">-transforming communities through innovative, child-centered learning.
-provides family fun and children's activites, many community leadership opportunities for teens, adults and groups.</td></tr>
<tr><td colspan="2">  </td><td>  </td></tr>
<tr><td colspan="3">Fig (11) kidtropolid: a city for kids, run by kids, a real- life kid metropolis, the child can choose different occupations that make a city work. It mirrors a real city and will allow children to participate in a real life experience.</td></tr>
<tr><td rowspan="2">Educational Spaces</td><td>  </td><td colspan="2">  </td></tr>
<tr><td>Fig (12) provide outdoor activites allowing diving into the forces and properties of water through waves, vortices and rapides, exploring the concept of hydropwer</td><td colspan="2">Fig (13) various activites offered by the museum to integerate the child in real life experiences</td></tr>
</table>

7-2 Digital Art Museum: Mori Building, Tokyo, 2018

Table (5)

<table>
<tr><td colspan="3">Mori Building: Digital Art Museum, Tokyo, 2018</td></tr>
<tr><td rowspan="2">Description/ Philosophy</td><td>  </td><td>   </td></tr>
<tr><td colspan="2">- The museum, considered a creative Paradigm shift
- An art collection, ultratechnoloigsts groups, aims to go through the integration of art, science over 10,000 square meters of complex floor space.
- “Borderless” idea express tearing down the borders, allowing visitors melting into the art becoming part of it.
-to inspire people to create new values and innovative new social frameworks.
(https://architects.team-lab.com/w/borderless/)
There are five distinct zones:
Borderless World, boundaries between art and visitor, person and installation, Digital artworks and installations are changing and transforming in response to people.
Athletics Forest, explore surroundings with body, fostering creativity, has installations that involve jumping and bouncing.
Future Park, an experiment for collaborative creation.
Forest of Lamps, an infinity room filled with sensitive lamps, lanterns that changes colors.
EN Tea House, watch flowers blooming in your teacup. patrons can sip tea from cups that bloom digital flowers until the last drop. (https://trulytokyo.com/mori-building-digital-art-museum-teamlab-borderless/)</td></tr>
<tr><td></td><td>  </td><td>  </td></tr>
<tr><td colspan="3">Fig (15) shows how children interacts and behave inside the space</td></tr>
<tr><td>Role of</td><td colspan="2">- Response and interaction between the visitor and the museum
- using the visitor’s body to explore the surrounding to promote creativity and spatial awarness
-creating a world where art and technology collide and where normal museum rules do not apply stimutalting the senses (Multi-sensory Experience), creating three-dimensional objects by utilizing digital technologies to express art
- creativity meets physical activity, bringing the digital age to the gallery room floor by which exploring the surrounding with your body, promoting creativity and spatial awarness</td></tr>
<tr><td colspan="3">Facilities used: projectors, lights, computers are used together to reproduce a world</td></tr>
<tr><td colspan="3">The five virtual exhibitions can be explored by visitors, which are generated by projectors and computers. The Digital light patterns that spill from one room to another, Borderless, evokes pre-cartography natural world. The living environment responds organically in real-time to movement and touch, adjusting visitor’s presence and altered usually by the interaction.</td></tr>
</table>

creative	- a portion of the exhibitions concentrate on creative spaces for children across the navigation of a multi-sensory environment. *'Athletic forest'* is an initiative promoting growth of brain. Visitors experience 3 D activities, a space to jump high and sink low, an area to navigate through floating, swinging bars, trying not to fall, and a large three-dimensional 'mountain' created with slopes of different elevations. Participants become immersed in interactive digital art across complex three-dimensional spaces that result in an interactive, physical and creative experience.

Fig (16) illustrated dynamic spaces that binds creativity with physical movement, encouraging spatial awarness skills

The aim is: sharing the visitor through co-creative participation to become more creative to dive into virtual reality immersing inside the art among the artworks and the connections morphing, transforming according to their presence

8- ANALYSIS OF CASE STUDY:

Table (6) illustrates summarized analysis of two children museums

	Spatial Dimension		**The human Dimension**		**Environmental Dimension**		**Physical Dimension**	
	Children Museum of Houston	**Mori Digital Art Museum**	**Children Museum of Houston**	**Mori Digital Art Museum**	**Children Museum of Houston**	**Mori Digital Art Museum**	**Children Museum of Houston**	**Mori Digital Art Museum**
Components of the architectural space:	**Some features of the outer**	**Flow interactive Separation**	**Defined and static**	**Changeable- Endless alteration according**	**Outdoor activities provided**	**Using smart materials, technology**	**Human scale. can be**	**Rely on sensation and changing**
Results	**Architectural spaces transformed to dynamics, interactive, movable. Such flexible spaces created helped in providing creative spaces for children and to interact positively**							
Special criteria for the visual vision of the space:	**Child get familiar with the**	**Perceived through lights and different**	**Traditional principles of design**	**Uses body and different senses**	**Fixed elements can't sense the**	**Can find solutions through smart**	**Shape fixed**	**Flexible and easy to develop**
Results	**Architectural Composition altered to communication, spatial elements, became easy to develop the spaces to house various technologies developing children imaginative skills and abilities promoting the child's creative thinking.**							
Criteria for the quality of the space:	**Fixed form**	**Separating inside and outside**	**Human scale**	**Immersion inside changeable environmen**	**Depend on natural and artificial lighting and**	**Depend on Electronic systems- adapted for**	**Traditional materials used**	**Interactive – safety factors for the child**
Results	**Architecture space transformed to interactive by the use of smart materials and IoT adaptability, affecting the characteristics of the space form. spaces include electronic systems and innovative technological methods, providing new dimensions to perceive the spaces to suit the child.**							
Conclusion	**Smart materials/ technologies bring opportunities to enhance architecture creative spaces for children.**							

8-1 Implementing smart technologies as a tool to stimulate creativity and imagination for children:

Creative activities help children to develop attention skills and cognitive learning. It encourages them to come up with innovative ideas and think outside of the box since creativity involves exploration and problem solving. Experts put some methods in order to foster and encourage children creativity include: -a space for creating, allow a free time, help kids activate their senses, discuss creativity, cultivate creative critical thinking, avoid managing, help kids pursue their passions Analysis of the case studies provide us with some lessons about application of smart technologies in children spaces. The proposed ideas to be implemented in children spaces based on the analysis and literature review shown Table (7), followed by a suggested strategy to implement technology in Architectural spaces.

Table (7) illustrates some proposed ideas to consider implementation smart technologies for children spaces (Author)



Fig (17) Interactive wall ideas for kids spaces

giving him more ability to textures and response	**Applied in Royal London hospital play space**	**Applied in National Museum of Australia**



Fig (18) shows some ideas: Interactive climbing wall, Discovery place, cave giving him a new dimension to perception of sense of place and scale




Fig (19) Interactive floor

let the child sense his environment and interact using touch and human scale, an interactive space using his whole body in a full immersive experience, providing experience on the physical, cognitive and emotional levels. Full immersion in space giving big sense of imagination to the child and using his body to sense the activity



Fig (20) interactive digital children library (https://www.trendhunter.com/trends/interactive-space)-

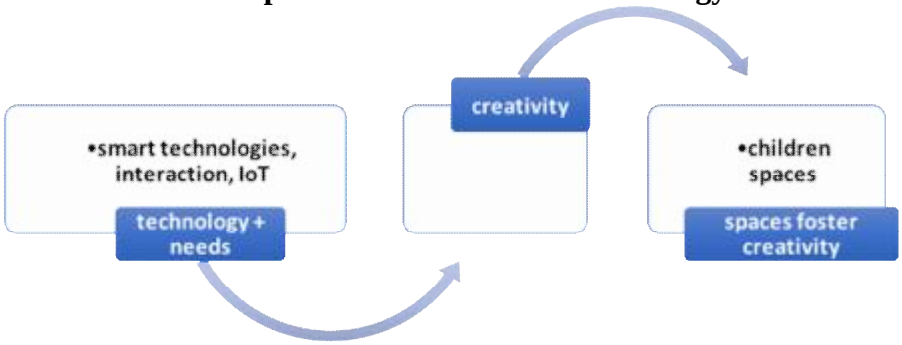
Interacting with spaces, learning by doing (https://instinctfurniture.co.nz/interacting-with-spaces-in-colombian-school/)

Ark of Nebra – Visitor centre Nebra, Germany

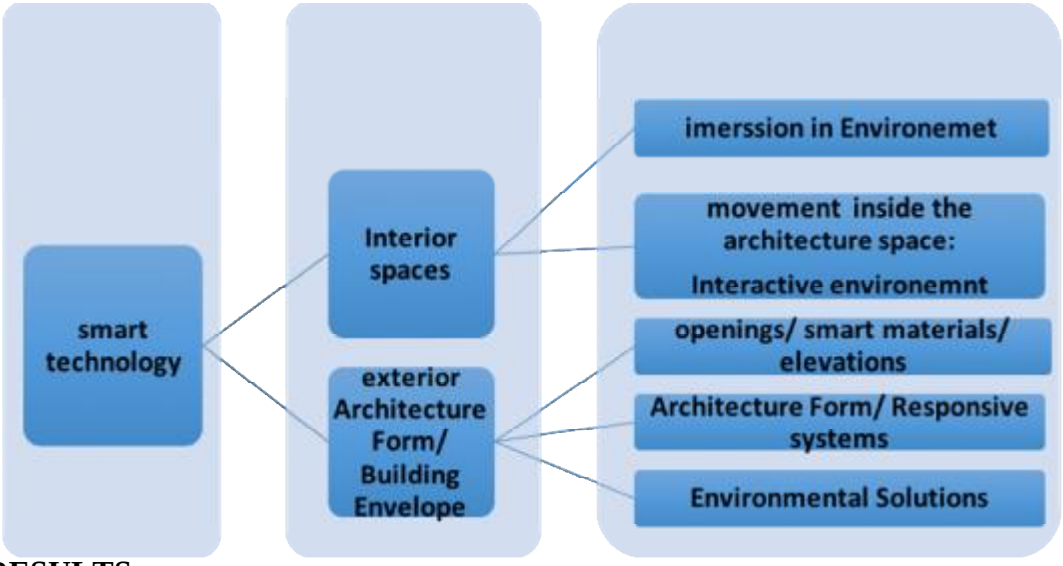
Expo 2012 Yeosu/ Korea – Malaysia Pavilion

Fig (21) interactive spaces inviting children for free learning
Children were able to integrate through the architecture, and dynamic spaces able to adapt for study and playing scenarios

Different tracks of the implementation of Smart technology and the effects (Author)



Suggested strategy to implement Technology in Architectural Spaces (Author)



9-RESULTS:

1-Smart technology has helped to create smart environments and opened up new opportunities to solve previous problems and give a new aesthetic dimension.

2-The manifestation of new technologies such as Internet of Things IoT, emphasis on providing environments and spaces that serve the human and provide him with comfort and safety

3-Digital technology has given new dimensions of time and space where the concept of defining and describing the architectural space in the third dimension has changed, but

extended to the element of time. The emergence of new spaces in architecture relied on digital entertainment and science fiction suitable for different ages
4-Technology and smart materials contributed to the response and solutions in the child's creative environment. Architectural design directed to the child must take into account the creative aspect of its development and stimulation, both in the outer spaces or interior Architectural Spaces.
5-Form of the child's Architectural spaces have been altered and transformed from conventional static spaces to dynamic interacting spaces offering flexible and adaptive spaces to children of different age groups. As well as interaction with the surrounding environment.
6-Appearance of new projects such as digital art museums aimed at inspiring the individual or create new social values and frameworks not only about the relationship of man with the space, but extended to include the relationship of the individual to the other. Where it aimed to engage the visitor with an innovative and creative experience
7- The development of creativity in the child helps him to develop different skills. Where he uses his imagination and encourages him to reach new ideas and think creatively and help him to solve problems. Where the role of architecture in providing creative spaces enhances the child's use of his senses and body and encourage the spirit of discovery and experimentation.
8- Smart technology included applications in both exterior and interior architectural spaces. External features included openings - facades- responsive systems and environmental solutions. The interior spaces included immersive environments, walk-through spaces and interactive environments.
9-Borderless: the idea of eliminating the borders between spaces which have been emerged by the new technology giving new dimensions in visual perception and increase awareness towards the spatial configuration increasing his imagination and intellectual skills towards his surround
10-Interaction: giving new and unexpected feelings by which endless responses can be offered

10-DISCUSSION

The purpose of this research was to investigate the potentials and role of smart materials and technologies and introduce the emergence of the Internet of Things to propose flexible creative environment for children. It was found that provision a range of spaces and good architectural elements requires the use of the child's diverse human needs and thus affects the child's response to the outside world. The major findings of the study are that Technological development has great impact in designing the architectural space of the child, Components of the architectural space, criteria for visual vision of space and criteria for space quality.

The study demonstrated the role of technological development in the development of architectural spaces for Children to Provide solutions to many complex human problems of the child, generation of new concepts of communication and interaction among them to exchange experiences, Provide the possibilities and facilities to know the extent of creativity of the child since its inception, satisfy his curiosity with experience and self-teaching and rapid incorporation of methods of communication and the speed of information transfer.
It is important to highlight that Smart technologies pave the road to new ideas in architectural design. This study showed some of its applications and how it gives different perception of time and space. Some advantages and disadvantages for implementing these technologies in Children Architectural spaces is summarized as follows Table (8):

Table (8) shows some advantages and disadvantages of integrating smart materials/ technology in children spaces on the child development (Author)

advantages	disadvantages
- giving the child new ideas to explore the environment around him	-Misuse of perception which may need guidance
- provide the child with the ability to live in a real experience physically and emotionally	- Further studies may be conducted to measure effects of such technology on certain ages
- utilizing the child's senses in exploring new sciences	- Some children may be afraid to try which needs more motivation and guidance in these cases
- increases motivation to finish tasks	- Technology can affect children's social development to human relationships affecting their focus
- develops problem solving skills	- Use of technology can have negative consequences on physical health causing vision problems
- more dynamic spatial skills	- Being over connected can cause psychological issues such as distraction
- enhances social interaction skills, the navigation of a multi-sensory environment, fostering the growth of the brain, and guiding spatial awareness skills.	- May affect mental health
- higher capacity for visual attention	- Slower development in social and life skills

11-CONCLUSION

Technology gives new dimension in aesthetics as it has the the possibility to change during time. Interaction between a user and space, making the space more visible, more dynamic, accessible and more friendly.

Smart Materials played a major role in changing dimensions of architectural space and influenced by new techniques such as Internet of Things IoT to create new dimensions of time and architectural space.
IoT (Internet of Things) emerged daily life and plays an important role in changing dealing with the architecture space, using automated processes to automatically control the building's operations.

These techniques have contributed to enhancing the creativity and imagination of the children, which requires increasing awareness of the educational goals, taking into consideration the technological development to keep alongside of the era and reflect it by providing creative spaces that serve the children as they are considered the main pillars who strengthen their creative sense and develop their imagination and thinking.

12- RECOMMENDATIONS

- Benefit of Smart technologies that transforms Architecture design, through the expansion of interactive surfaces, to discover new design possibilities.
- encourage multidisciplinary collaboration between Architects and Technologists.
-Benefit of nanotechnology which offers superior potentials result in novel smart architectural solutions.
-Technology can affect different disciplines: Education, Architectural spaces and Environmental aspects. It is recommended that additional research can be done in different areas that affect directly child's creativity development.

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