Conceptual Context- Based Awareness Model for Designing Smart Educational Spaces Environment

Heba M. Jahin, Ali F. Bakr, Zeyad T. Elsayad

***Abstract*—** As Smart educational environments can represent a specific type of pervasive systems in which the people's surroundings are enriched with sensing and actuation capabilities, with the purpose of improving the user experience to remain focused on the interaction between the users, their activity, and their behavior in the space. That goes by being aware of the environment contexts and automatically adapt to their changing context-awareness, interacting with their physical environment through natural and multimodal interfaces. Also, by serving the information used proactively. Hence, to find the best way to understand, design, and handle the problems of educational needs and requirements in smart spaces environment there must be a new approach to connect the smart environment and the educational needs based upon studying the context of the smart educational spaces environment.

This paper suggests a computational framework through designing context-awareness model to help in designing smart educational space environment by creating a field of changes and modifications, generating possibilities, and gathering data about the users of the space, spatial and temporal information, (ICT) information and communication technologies used in space, and the physical, structural, and user context needs of the designed environment.

Therefore, the generated context-aware model will help in designing smarts educational spaces environment that can be adapted and controlled to answer the users' defined goals, needs, and activity.

***Index Terms*—** Context-awareness, Contextual Information Data analysis, Design process, Smart Educational spaces environments.

I. Introduction

The design of the smartness in educational spaces environment mainly concern about learning and changing all the time to fit the profiles of users and their interactions [1]. Those educational spaces must designed to be a working environment with embedded computers, information appliance and multi-model sensors allowing each user of those spaces to perform their tasks efficiently [2]. Those spaces have a kind of perception, cognition, and analysis, anticipation about users and it's surrounding as its artifacts also, have the processing and communication capacities to interact with each other by being aware of all its contexts and automatically adapt their change based on its context-awareness model [3]. Furthermore, that smart educational space will be closer to a system that orchestrates components such as sensors, actuators, smart materials, mobile devices, software agents, management system, and also the space users' to perform a desired function [4]. To design smart educational spaces it needs to specific design approaches that have the capacity to deal with all different type of collected data, information and, interconnected technologies and can easily handle it. Those Approaches can automatically generate numerous of smart architectural proposal and alternatives based on context-awareness models and semantic knowledge extracting from existing precedents smart spaces.

Hence, this study involves what calls context-awareness as the most common and important process in designing smart architecture to study the needs and requirement of the smart educations spaces, as the context concept is defined as a whole of circumstances in which an action is, or which surrounds a design scenario and makes it possible to be understood [5]. Thus, the context awareness system is sensitive to the elements surrounding the inhabitant, as having the ability to observe users, and collect information on its environment in order to offer an adapted service. Therefore, Context means situational information, and context-awareness means that one is able to use context information. A system is context-aware if it can extract, interpret and use context information and adapt its functionality to the current context of use [6]. That means that the research will study the relation between the educational spaces and its component, and their users.

The focus of that research is to build up a Conceptual Context-Based Awareness Model for Smart Educational Spaces (CCBAM) base on Dynamic Process Model for Smart educational Spaces (DPMSES) [7]. This framework is based on the principles of context-awareness to include the smartness in designing different type of spaces .The CCBAM is a context-based process having a mixture of analogue and digital data base to help in exploring smartness in the designing of educational environment by being aware of the its surrounding and easily changing and adapting to the space and user's needs as it help the designers to see all the possible scenarios, context and their different usage.

This paper consists of three main parts: 1) the definition of context, context- awareness, and context-awareness system , 2) the definition and needs of smart space and smart educational spaces, 3) the Conceptual Context-Based Awareness Model for

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Smart Educational Spaces (CCBAM) is proposed.

II. CONTEXT- BASED AWARENESS SYSTEM (CBAS)

A. context

As the comment definition of context is "*Any information that can be used to characterize the situation of an entity (...) relevant to the interaction between a user and an application, including the user and the application themselves*". As can be observed from this definition, any information source can be considered context as long as it provides knowledge relevant to handle the communication between the user and the system. In addition, the user is also considered to be part of the contextual information [8]. The context is a structure or a frame of reference, and situational information that can be used as a mechanism to manage, organize or reason about knowledge [9].

B. Classifications of context

The classification of the main types of context by time of Unicom system environment and according to that Morse et al., respect the type of environment [10]: physical, human, and ICT. The human user context defines the user's tasks to achieve goals and defines the social and physical or environment context.as shown in table .1

TABLE. I A GENERAL ARCHITECTURE FOR CONTEXT INFORMATION

characteristics	Descriptions
Physical environment context	
what	Type of physical environment or physical phenomena context-awareness such as awareness of temperature, light intensity, chemical or biological concentration.
where	Spatial awareness or location awareness: where an awareness of context can be exploited. This can be at the current location or in terms of one location in relation to one or more other locations.
when	Temporal awareness : when context-awareness is useful-now, later and during some activity this can be defined in term of an absolute time in terms of relative time to some other event or condition
ICT environment system context	
How	ICT awareness is aware of how any context is created and adapted over an ICT infrastructure .e.g., a context or context-aware application can be accessed over a wireless link and via a mobile terminal
User environment context	
who	User context-awareness: who might benefit from an awareness of someone's context. The user context is divided into personal and social user contexts. The personal user context can be subdivided into : personal identity context, personal stereotype, and user activity or task context. Social (user) context: describes how the actions of someone may affect others.
Goal context for application or user	
Why (task)	User or application goal : why a context is useful , the higher-level application or user purpose the context is used for ,e.g., a location serves to show someone or something in relation to their destination Context adaptation : how the current context can transition to the goal context

C. Context-awareness

Context-awareness is techniques for developing pervasive computing applications that are consider as a flexible, adaptable, and capable of acting autonomously depends on behalf of users [11]. Context-awareness [12] has been presented as one of appropriate modeling paradigms where the identification and adjustment of behavior according to specific conditions are primitive concepts. It provides the means to partition the operation of complex systems such as smart buildings into "scenarios" (or situations) [13], where knowledge, strategies, parameters and objectives are organized. Hence, a context awareness system is consider as a very sensitive paradigm to the elements surrounding the inhabitant, as it can observe the inhabitant, collect information on its environment ,extract, interpret , use context information and adapt its functionality to the current context of use in order to offer an adapted service [14].

D. Context-Awareness system

The term context-aware system is used to refer to systems that use context to provide relevant information and/or services to the user, where relevance depends on the user's task [15]. The basic context-aware model consists of four main components: current context capture, goal context creation, adaptation of the current context to the goal context and context management [16]-[17]. As shown in fig.1. The context-aware operational life-cycle [9] consists of: (1) the physical, human and ICT environment context, (2) data is created, (3) the user goal contexts needs are created, (4) the environmental contexts are used to adapt user or application goal context, (5) the context data need to be managed.

A context-aware system is particularly characterized by the following characteristics [18]:

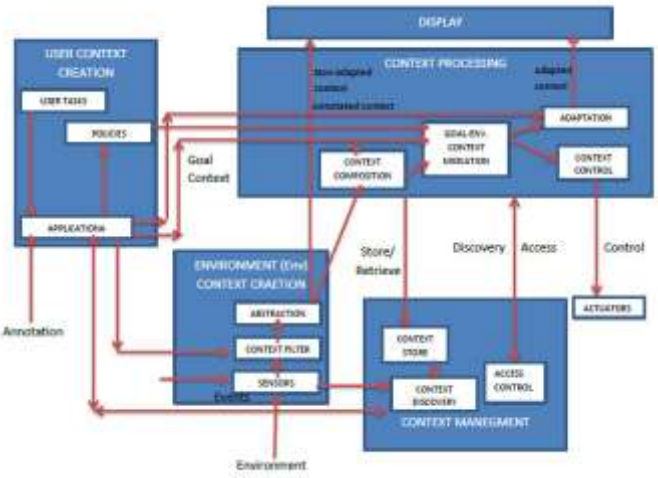

Fig. 1 a general architecture for context-aware systems

- Aware of its surrounding and situational context information.
-Personalize and tailor to the users' needs and context of interest.
- Adapt to the continuous changing of users' needs and ongoing tasks.
- fit with the dynamic and mobile nature of users' activities and tasks

E. Context- awareness system architecture components

Based on the design process model for design smart spaces the architecture[7]of the context that may use to form the context- awareness system which can be classified into four main parts , As shown in figure 2. And can be connected together in the interaction model. The four models are:

- The spatial context data model :

Handle with the non-geometric information attached to a space and specify:

The space domain which represent the type of the space, the activates taken place in the space, they are of the space, and define the different type of users which may use that space

The space type as each space even in the main domain may different in furniture, temperature and location.

- The virtual users data model:

This model handles with the special information about each user of the space as everyone have its own behavior and unique characteristics ;so that it is very important to study well every user and its needs in the designed space.

- The building data model:

This model includes spatial information to explain the configuration and the hierarchy of the building design components , starting from the building domain , the plan information(area and location) , the walls (area , location , and number) , the opening in walls (doors , windows, their location ,size, and area) , the stairs , the structure element (beam , colors , slabs) , and the building levels and surfaces.

- The object data model :

Which contain object function and statue to interact with users and other object as each object activated according to a specific event performed by the users, that model contains all the furniture, equipment, and appliance which have sensors to simulate the interaction in the real world.

All those data models will merge together to perform the interaction data model which connect all the components (space, users, object, activities, and event)

The interaction model motivate the concept of human-centered design as this model represent the interaction between the smart

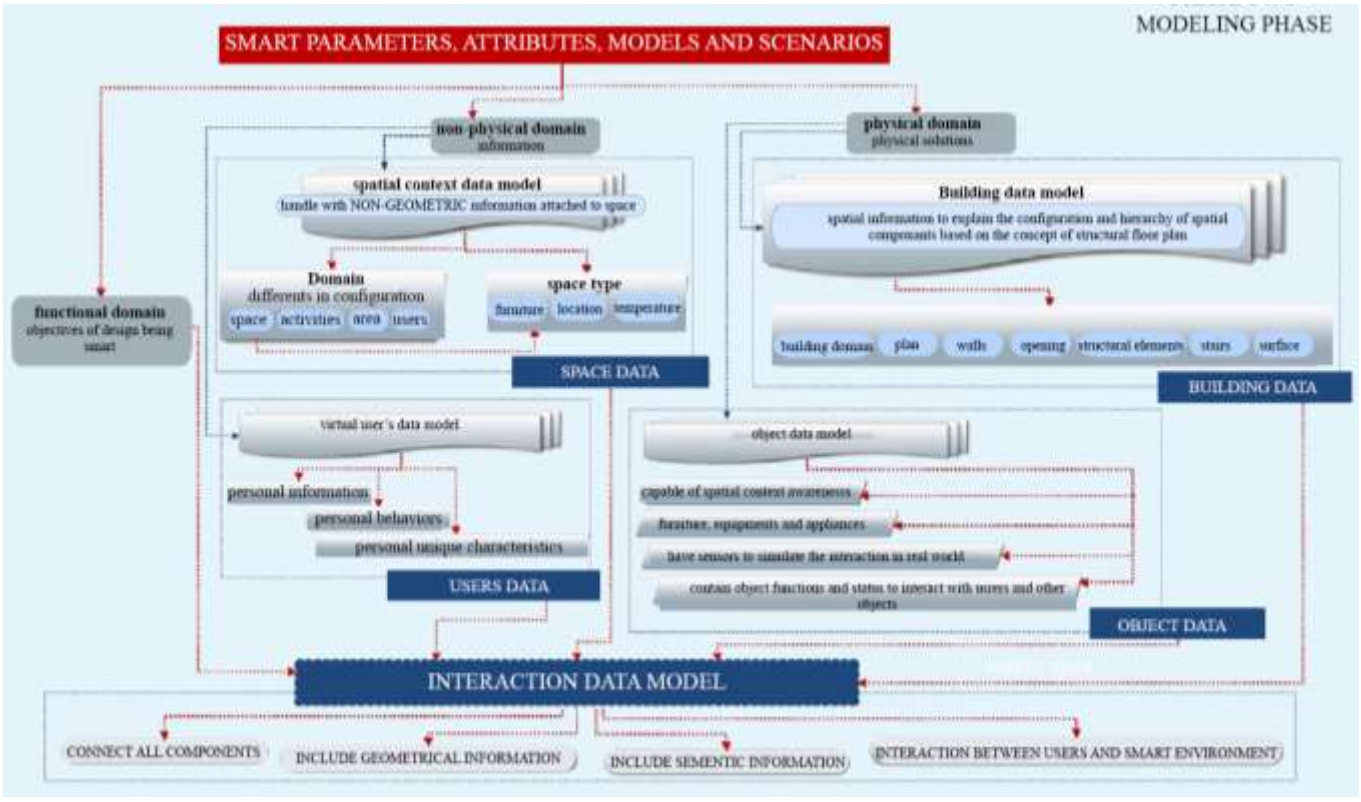

Fig.2 a general model for context-aware component

environment and the users as a semantic information between the users ,object ,and space.

The context- awareness model represent a very important process in designing a smart space or design as it considers a main based semantic information model helping the design and space generation .

III. Smart Spaces

Smart space is any real or virtual location equipped with passive and active artifacts. These artifacts can be any kind of sensors and actuators, mobile devices, software agents, management systems, and also human beings. These artifacts have the processing and communication capabilities to interact with each other in a beneficial way [19]. It can be defined as an environment that is capable of acquiring and applying knowledge about the environment and its inhabitants to improve their experience in that environment. The goal of smart spaces is liberate the users from the mundane tasks that they manually perform to change their environment and meet their requirements [20]

IV. Smart Educational Space

To design smart educational spaces it is necessary to augment physical sensors with other kinds of data to create more reliable and truly context-aware smart educational spaces [20]. To design the smartness in spaces it is needed to show concepts that can be derived from the introduced scenarios, specification, and concepts. Then, define that scenarios by using algorithms .While scenarios and algorithms are specific in that they describe individual cases; the concepts and specification are defined in a general way[21].that means that to design that type of spaces we need to focus on the needs and scenarios, context-awareness, and computing methods.

Research on learning spaces studies highlight the influence of the physical space in learning practices [22]. The physical space is considered a changing agent that has an impact on learning: it affects how one learns and how one teaches. Space can shape users' interactions and activate collaborative learning .Whether physical or virtual; the space becomes a determining contextual factor in blended learning scenarios by enabling or inhibiting learning [23]. Diana Oblinger states in her book "Learning Spaces", *"a particular space can bring people together; it can encourage exploration, collaboration, and discussion. Or, space can carry an unspoken message of silence and disconnectedness"*

Learning environment [24] as much as in any other environment, psychological processes can influence learning, teaching, and well-being of individuals in many positive and negative ways. Such processes include arousal, adaptation, stress, distraction, overload and fatigue, but also the effects of lighting, color, noise, heating, cooling, ventilation, and equipment and furnishing.

V. Smart Educational Space Needs

The essential need of smart educational spaces should be contributing to a positive educational quality of the learning environment [24] - [25]. Users should be stimulated to engage in individual investigation and exploration through an appealing design of the spaces, with workshop-like classrooms and a variety of materials. This will create a variety of forms of learning environment to stimulate user's senses and achieves active interaction with the environment. The smart educational spaces should not only meet functional requirements but also have a variety of qualities of educational and esthetic nature. The main needs of space will be summarized in the following points:

A. Psychological Processes

Psychological processes can influence learning, teaching, and well-being of individuals in many positive and negative ways. Such processes include arousal, adaptation, stress, distraction, overload and fatigue, but also the effects of lighting, color, noise, heating, cooling, ventilation, and equipment and furnishing.

B. Spatial Perception

To perceive something is an active process. We don't only see an object, we also feel, smell, taste, and hear it. All our senses are involved. But sensory reception must be processed in the brain. This will then generate the overall understanding of the situation in time and space.

C. Sensory Perception of Architecture

Architecture acts on our senses in various ways. We all see spatial forms and colors, feel and smell building materials and surfaces, hear the sound of spaces, sense the warmth or coolness of the different materials. Beyond these familiar sensory perceptions, little thought has been devoted to sensations such as the sense of equilibrium (vestibular sense), of one's own movement (kinesthetic sense), and the various receptors for the sensation of our own bodily functions (somatovisceral senses), all of which are significantly involved in the perception of architecture.

D. Spatial Conditions

A space is much more than four walls, floor, and ceiling. The spatial conditions that should be considered for human well-being include color scheme, lighting, heating, cooling and ventilation, acoustics, smells, and furnishings. All these aspects can significantly influence the sense of well-being and readiness to learn, and therefore also learning performance.

E. Color Scheme

Color is an important factor in the design of the learning spaces. The effect of individual colors is depends on intensity, contrast, size of the surface to be designed, and the interactions with other colors. In addition, the effect of color has a close relationship with illumination and therefore dependent on the light planning in the space.

F. Acoustics

Current research shows that noise and bad acoustics can severely impede teaching and learning. Today learning spaces environment can be designed to optimize the acoustic relationships for users of the space.

G. *Space dimensions*

The dimension of the learning space effects on the creation of the optimal condition for the sight and hearing of the spaces user's. The proportions of spaces encourage natural illumination and ventilation, which is demonstrably crucial to the learning success.

VI. THE CONCEPTUAL CONTEXT-BASED AWARENESS MODEL FOR SMART EDUCATIONAL SPACES (CCBAM)

This conceptual model (CCBAM) goes through three main phases, and mainly concerns about building a context database that can help architect to design smart educational spaces especially smart classrooms, as shown in figure 3:

A. *Phase one: Building the Context Database:*

This phase mainly concern about collect a long check list about the entire context that will be used in designing smart classroom as the context data about (users context data, activities context data, ICT technologies context data, and physical environment context data).

B. *Phase two: Building Context-Awareness Database:*

The context- awareness database model represent a very important process in designing a smart classroom space as it has the main base semantic information model which will help in designing and generating the space's different scenarios . As this database model represents the interaction between the smart physical environment, the users, the activities and scenarios of space, and the ICT technologies used in space as a semantic information and relation between the users, object, and space

C. *Phase three: Examine the Smart Classroom Scenarios:*

In this phase a 3D virtual model will be presented with more than design scenario (2 or 3 or more scenario) which will represent a possible solution based upon the contextual information data which represented in phase one, all those scenarios will be examined based upon the context-awareness relationships to know the best smart solutions for all possible scenarios to design smart educational space (classroom).

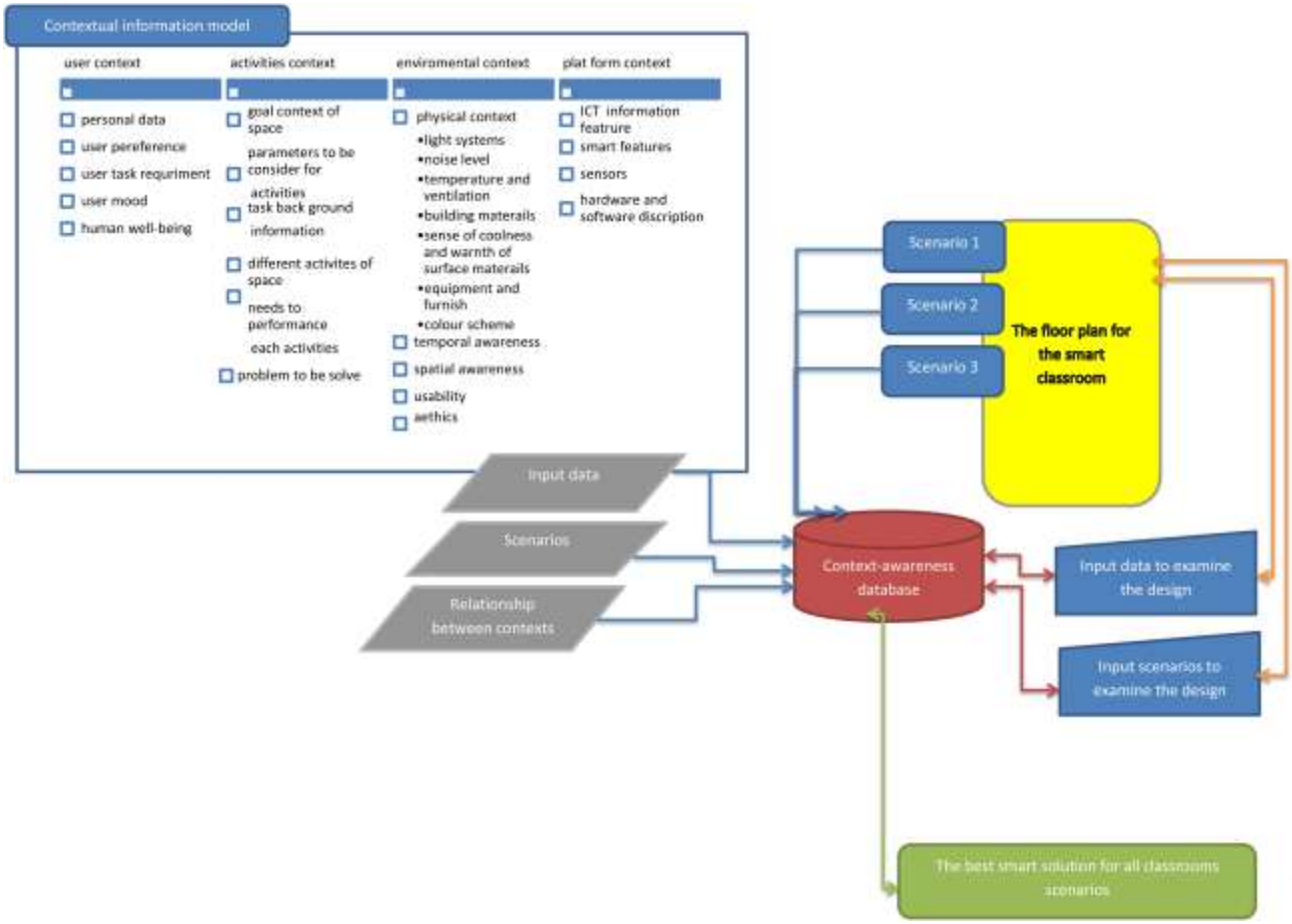

Fig. 3 a general architecture the conceptual context-based awareness model for smart educational spaces (CCBAM)

VII. CONCLUSION

Summarizing, this paper puts forward a novel approach to deal with contextual information in designing smart spaces, which takes into consideration principles and roles of designing context-awareness system as a system can control a heterogeneous types of data, This work represents a conceptual design process based upon the context data information, and the principles of context-awareness system design for helping architect to design smart educational spaces.

The proposed CCBAM concern about gathering context information about the users and environment needs so that the design will be smart enough to answer those needs by making different classroom scenarios to represent the possible solutions. Then those data (users, physical environment, functional and activities, and the ICT information) will be classified in context-awareness system model so it can easily create a relation between all the data about the users and the smart educational environment.

Using to some design process model like the one proposed in the paper CCBAM can help designers and architect in understanding and generating contextual information about the smart feature and elements in educational spaces especially in smart classroom design in the pre-design and design phases. That model will change in the designing of the smart educational spaces environment; as it help is using the new information and communications technologies from the process of gathering data until the process of testing the final design and not only in the occupation phase of the design.

Finally, this study gives a survey on the context-awareness systems and their capability to open new approached in designing smart educational spaces which appeared in the applied CCBAM framework neglecting applying the result in more examples, as that part will be appeared in further work.

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