THE IMPLEMENTATION OF SMART TECHNOLOGY AS A SUSTAINABLE TOOL IN THE STUDENTS' DESIGN STUDIO PROJECTS

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Abstract

The consideration of sustainability concept by the building industry in the developed countries since 1970's has promoted continuous search and invention of technologies that would be capable to convert this concept into practice. One the technologies invented so far is the smart building technology which consists of electronic interfaces and devices that can be considered in the design of building at the design stage and later fitted into building's structure or fixtures during the construction stage. The implementation of smart devises would help users to manage the living conditions of the internal environment or - in other terms- to provide a comfortable and sustainable environment. The smart technology has not affected only the design of buildings but also how the architect interprets and resolves the design problem. Architecture students should design buildings that respond effectively to the end user needs. To do so, they should be aware of the smart technology and how it can be applied in design studio projects as they will practice later – as architects- the application of smart technology in building's design. A pre-assessment survey had been carried out on students of College of Architecture and Planning, King Faisal University to find out the level of awareness of students of the smart technology. The survey showed that students have little knowledge about smart technology and few students had actually applied this technology in design studio's projects. This paper demonstrates the survey findings and provides explanations of why students are not aware of this technology. It recommends an approach that outlines the possible incorporation of the smart technology concept and applications in the architectural design curriculum. This would raise the students' awareness of the technology and help them to apply it in their projects and to create sustainable design projects.

1. Introduction

Brundtland (1987) defined sustainability as:" *Development that meets the needs of the present without compromising the ability of future generations to meet their own needs*". The consideration of this concept by the building industry in the developed countries since the 1970's, has initiated the invention of new tools and techniques such as smart building technology that would be capable to apply this concept practically. Smart technology can be defined as the technology used to make all electronic devices in a building act "smart" or more automated. The smart technology aim is to help people including those who have special needs i.e. disability to control the environment that is around them whether it is at home, at the office or anywhere else.

A smart home is a home that equipped with special structured wiring and devices that enable occupants to remotely control or program an array of automated home electronic devices by entering a single command. For example, a homeowner on vacation can use a Touchtone phone to arm a home security system, control temperature gauges, switch appliances on or off, control lighting, program a home theatre or entertainment system, and perform many other tasks (SearchSMB 2007).

The smart home technology products and services play an important role in creating benefits for users. In general, smart products and services can be divided into six categories (Roe 2007) namely: comfort, energy management, multimedia, and entertainment, healthcare (European Senior Watch Observatory and Inventory 2002), security, safety and communication. In this sense, smart technology can be considered as an integral part of sustainability. Protocols and standards for the design of controls and interfaces of smart homes were set up by a number of organizations around the world such as INTEGER in the UK (Integer 2004a, b), TechHome CEA in the USA (Consumer Electronics Association 2004) and Konnex Association in Continental Europe (Konnex Association 2004). Some examples of smart projects in Europe include INTEGER in the UK, smart home technology projects in the Netherlands by the Smart Homes Association (Van Berlo 2005, 1997, 2002, Van Berlo et al 1999 a & b, Bierhoff 2006 and Bierhoff et al 2007), and SENTHA project in Germany (Fellbaum, Hampicke 2006).

Venkatesh and Mazumdar (1999) and Venkatesh et al (2001a & b) highlighted that the smart technology should be integrated into other living spaces, such as physical, social to make up the whole notion of home. In addition, Dewsbury, G. et al (2007) pointed out that smart technology should not be 'added' into the home, it should be an 'integrated' part, forming a seamless integration into the fabric of the dwelling when possible. The technological home of today and tomorrow embraces technology within its structure. Smart technology should be thought of as an essential part of the design of the building elements and not an after-thought. Such consideration would create smart building elements that are capable to be interactive with user daily requirements and adaptable to respond to the user's changing needs. The resulting design product should be aesthetically pleasing, non-invasive, reliable, individualised dependable systems that should assist the person in maintaining a way of life that they wish to maintain.

Architects should have good knowledge about smart technology that enable them to make the correct decision concerning the most appropriate, available technology that is cost effective in order to provide the appropriate design of home technology to the user (Dewsbury et al 2001). As the smart technology should be an integral part of the design of buildings, designers should seriously take it on board, develop good awareness of the technology, and how to consider it as one of the factors that would affect the final design product. The designer responsibility is to choose the appropriate smart devices, check that smart devices are correctly integrated i.e. correct configuration, position, location, appearance, form, function etc, with each element of the building. Thus, the user interaction with two worlds: the real world represented by the building elements and the virtual and smart world represented by the smart devices is comfortable and offer complete help and support to the user.

The College of Architecture and Planning sets its' new vision as *'Towards Sustainable Architecture',* and the College is eager to apply sustainability concepts in all theoretical, practical and design courses. Therefore, this research argues that sustainability including smart technologies should be taught to students during the academic stage and preferably at third year level as they have the basic environmental knowledge from their environmental course which is in year two. Students should have sound academic knowledge that would enable them to implement it in the design studio and real life design projects as well. At present, the smart technology is taught at very limited scale at the College of Architecture, King Faisal University, Kingdom of Saudi Arabia, through a tutoring course. This paper discusses the student's awareness of this technology and the possible application of the smart technology in the design studio's projects.

2. Research objectives and Methodology

The research has a set of objectives and these are:

- To find out the extent of student's awareness of smart technology and whether it was implemented or was considered in design projects
- To seek explanations of non implementation of smart technology in design projects.

- To set recommendations of how to integrate smart technology in architectural education.

To achieve the research objectives, it is argued that a combination of quantitative and qualitative research methods is needed. The use of mixed methods is because the findings that relate to each method will be used to complement one another and at the end of the study to enhance theoretical or substantive completeness (Ausubel 1968).

Prior to the use of survey tools, the author undertook an observation and chats with few students of years 4 and 5, and he found that students have little awareness of this technology. Thus, it was necessary to find out the level of fourth and fifth year student's knowledge about smart technology and whether this technology have been considered in design projects in order to make recommendations of how to include it in the architectural curriculum. To assess the student's knowledge and views about the smart technology, it was suggested to use a survey questionnaire as a pre-assessment tool to examine the level of student knowledge and awareness about this technology. Researchers as Ausubel (1968) & Meyer (1993) recommended the pre-assessment for several purposes such as: to assess student prior knowledge and to provide the basis for the implementation of teaching syllabus into the educational curriculum.

A questionnaire survey was used to target 137 students who are in the fourth and fifth year at college of architecture and planning, departments of Architecture and Building Technology. Fifth and fourth year students were chosen because it was presumed these students should have advanced architectural and technical knowledge than students who are at lower levels of study. A questionnaire was prepared to inspect the student's views about the following aspects:

- Their level of knowledge about each component of smart technology
- The implementation of smart technology in the design studio projects, and what were the reasons of non-implementation.
- Their perception of the level of effect of the implementation of smart technology would be on the various aspects of the design of buildings

The questionnaire was launched on the Intranet page of the college of architecture in June 2007, for around two weeks. At the end, the total number of respondents was 64 which represent an overall return of 47% which is high return percentage of such Internet questionnaire survey. However, the sample size (i.e. number of respondents) was too small to allow anything but simple statistical tests so the following tests were applied on the links between the variables:

- The means values calculations where the mean value for each category of the 'implementation' variable is calculated and assigned to a designated category of the explanatory variable. This would show the degree of proposed effect of each of the explanatory variable on the designated category of the usage variable.

• Cramer's test of correlation: to examine the strength of relations between variables.

• The Chi-square Pearson or test of significance: It examines the probability of these relations to be held in the population.

To know the reasons of why students do not implement smart technology in design projects, a number of interviews were carried out. The target of these interviews was to find out whether there are any constraints on the implementation of smart technology in design projects and why students were unhappy to implement them.

3. General results concerning smart technology

Students were asked whether they know a number of smart technology components. 31% of the respondents said they do not know about voice recognition and movement track devices. 19% to 28% said that they do not know about electronic medical Devices and medical aids, environmental Control Systems, virtual clinic/hospital tools, homecare facilities, tele-services through the Internet, individual wellness monitoring tools and electronic equipment's aids for daily life. Remote administration tools for monitoring and control of building systems are not known by 17% of respondents. Less than 15% of the respondents know about life safety System, building electronic networking, Internet appliances and security and anti-burglary system. 6% only do not know about energy management system. The level of knowledge of students seems to be high so far about most components of smart technology. However, further tests need to be carried out to see how far this knowledge is technically sound.

Students were asked about the possible implementation of various components of smart technology in the design studio projects. Nearly more than half of the respondents said that it is possible to consider the electronic medical devices and medical aids, security and anti-burglary system, and virtual clinic/hospital tools. On the other hand, the same percentage said that it is not possible or it is difficult to implement remote administration tools for monitoring and control of building systems, voice recognition, movement tracking devices, Electronic equipment's aids for daily life, homecare facilities (see appendix A, table 1). 69% of respondents said that it is possible to implement energy management system in project design. Around two third of the students said that it is possible to implement the following smart technology components in project design: life safety System, building electronic networking (i.e. Wired, Wireless), Internet appliances: webcams, web phones, video walls etc. 60% said it is difficult to implement an individual wellness monitoring tools and the same percentage of respondents said it is difficult to implement tele-services through the Internet (see appendix A, table 1).

Few respondents said that they had actually implemented smart technology in design projects. 33% to 39% said they had applied energy management system (EMS), life safety system, and building electronic networking. 16% to 27% said they had applied Internet appliances, remote administration tools for monitoring and control of building systems, voice recognition, movement tracking devices, environmental control systems, electronic medical devices and medical aids, security and anti-burglary system, electronic equipment's aids for daily life, and tele-services through the Internet, virtual clinic/ hospital and homecare facilities. Only 11% of the respondents said they applied individual wellness monitoring tools in their design projects (see table 1, appendix A). Students were asked about the reason of why the smart technology had not been implemented in design projects: 75% said it was difficult to implement and 67% said that it was out of scope of the design project, whereas half of them said that they do not know how to implement it. The explanation of non-implementation of smart technology in design projects is mentioned in section 6.

To find out whether the students have sound knowledge about the smart technology and its application in buildings, students were asked about the effect of smart technology on a number of building features and building design aspects. In accordance to the building behaviour, around two third of respondents said smart technology would positively increase the conservation of energy of the building, the capability of spaces to accommodate new complex activities and ever changing technology. 78% of respondents said it would improve the security of the building (see table 2, appendix A). 53% to 59% said that smart technology increases the following features of a building and building design: the flexibility of spaces, the designer ability to adapt spaces and the complexity of the building services such electricity, drainage, computer networking etc. (see appendix A, table 2).

40% to 50% of students said that smart technology would have an increase impact on some features of a building's design (see table 2, appendix A). However, more students were expected to say that smart technology would increase these features i.e. flexibility, adaptability of the building, the complexity of building services and design of intelligent elements of building (see the argument in table 1). More students were expected to say that smart technology has improved the energy conservation of the building. The only satisfactory vote was towards the building security (see option 10, table 1).

Table 1: Students response and the expected response in regards to the type of effect of smart technology on building design (question 3)

Effect of the smart technology on the design of buildings	Percentage of Students who vote for the increase option %	Expected response of percentage of students who should vote for the increase option
1. The building spaces in terms of adding up additional spaces such as control rooms	42	As smart buildings became networked, spaces such as control rooms and shafts are required. So more students are expected to vote for this option
2. Complexity of designing the building facades	47	As building facades became smarter, more students were expected to vote for this option
3. The complexity of designing the elements of the building such as walls, door and windows	50	As building elements became more intelligent, more students were expected to vote regarding this option
4. The possibility of incorporating adaptable fittings to the user needs such as these used in WC, Bathroom and kitchen	52	Smart fittings should be adaptable to the user's needs, so higher percentage of students were expected to vote in favour to this option
5. The designer ability to adapt spaces in terms of joining spaces or separation of spaces	53	Smart technology should give the designer more ability to adapt spaces, so more students were expected to vote for this option
6. The complexity of the building services such electricity, drainage, computer networking etc	58	As smart building services became hi- tech and complex, more students were expected to vote for this option
7. Flexibility of spaces in terms of the possibility of changing the use of internal spaces	59	As buildings became high tech thus flexible, more students were expected to vote for this option
8. The capability of spaces to accommodate new complex activities and ever changing technology	61	Smart spaces are intelligent and interactive, so higher percentage of students was expected to vote
9. Positively the conservation of energy of the building	69	As smart buildings are energy conservative structures, more students are expected to vote in favour of this option
10. The improvement of the building security	78	Most students gave the right answer

The little vote of students towards the positive effect of the smart technology on most of the building features would be another indicator which demonstrate that student have broad knowledge about the smart technology but this knowledge is not sound enough to enable them to judge how this technology would really affect buildings.

4. In-depth tests' results

The in-depth tests found that students who do not know how to implement the following smart technology components: energy management system, life safety system, and Virtual Clinic are those who said that do not know about it. Students, who said that they do not know about voice recognition movement tracking, are those who did not consider it or those who said they did not apply it in design projects (see table 3, appendix A).

5. The interview results

Students pointed out that there are other reasons of why the smart technology had not been implemented. One of them highlighted that he considered only the constraints that are required (e.g. site constraints, environmental and climate factors) which would guarantee his success whereas taking other constraints would be risky for him.

Students have a concern that they would be criticized by the jury if they implemented the smart components in is the design project. One of the students pointed out there was hardly enough time to do the design project and he is not aware of this technology and no one had explained to him how to implement it in design projects.

A student pointed out that some design studio instructors constrained themselves with the old teaching systems and are reluctant to adopt or accept new systems or fresh ideas. Another said: "*if the student feels the impact of the smart technology on design project or building design thus he would use it. The student should feel the importance of the smart technology and what it offers to the architect and the positive aspects that it would add to the building and how it would enrich the architectural design*". Students also pointed out that few of the smart technology components had been taught through a theoretical course in the second academic year but not to the required depth that enables students to use it in design projects. They suggested that it should be in the design studio subject as the student would not be able to understand how to apply it in the building design if it was taught as theoretical subject. Students suggested that College of Architecture should invite smart technology expertises who can give lectures about it.

6. Discussion and conclusion

The results showed that so far, most students have little or average knowledge about the smart technology. These results were expected as few components of smart technology were taught previously through a technical course or in thorough in the theoretical course. In depth analysis of the results showed that students who did not know about a number of smart technology components are those who did not know how to implement them.

Students highlighted to a number of constraints that would hinder possible implementation or consideration of smart technology in design projects, these are:

• Little sound technical knowledge of student's about this technology as there is no previous technical courses that teach such subject exist, neither at the college or department level
• The time constraints of the study term
• Students concern of possible criticism from the instructors and jury
• The attitude of some instructors who refused the implementation of the technology in design projects and asked students to abandon it.
• Risk of dissatisfying the design project's jury and the student's concern of possible failure

A clear teaching strategy thus, should be defined and applied to overcome these constraints and to help students to understand this technology and implement it in their design projects. Leal Filho (2002) suggested a number of guidelines in respect to promoting sustainability teaching and curriculum design in Higher Education (HE). The researcher suggests these guidelines can be tailored and used for promoting smart technology teaching. The tailored guidelines would include the following:

a. Smart technology should not be seen as a discrete discipline. The introduction of smart technology into the curriculum involves the provision of new skills directed towards the understanding and achievement of a harmonic 'people-environment-nature' relationship.

b. Smart technology is not the exclusive preserve of one established discipline. It is part of a shared life and common domain. It is interdisciplinary in its philosophy and focus

c. There are many and flexible approaches to teaching smart technology. The main pedagogic thrust should be towards raising consciousness. Jüdes (2000) argues that providing positive ideas or visions will be more instructive than catastrophic scenarios; when challenged people are able to devise unexpected and imaginative solutions to problems.

d. The precepts of smart technology need to be demonstrated. The best way to reach out to people who do not understand smart technology, or who resist the philosophy, is to demonstrate its essence and practical application.

e. Systematic progress in teaching smart technology cannot be made without changes in the content or focus of curriculum

Hayles & Holdsworth (2008) described the way that they teach sustainability to students. The students are taught sustainability principles using different research methods so that they better understand the often-complicated decision making that surrounds sustainability issues. They also have the opportunity to visit innovative green building projects, undertake building audits, question experts in the field, and study their own impact on the environment using interactive web-based tools. Students carry out group-work research in an area of sustainability. In addition they are asked to complete an independent literature review on a topic relating to one or more aspects of sustainability, showing that they have grasped the key concepts and can apply critical thinking in their approach to developing a research question for their final year project. This approach can be used through a theoretical technical course that teaches students the fundamental aspects of the application of the smart technology components in the design of buildings using real life scenarios.

The application of the smart technology in design studio projects requires a methodology that utilizes Anderson and Krathwohl (2000) learning cognitive taxonomy and enables students to produce innovative sustainable projects. The methodology is suggested to be according through the following steps:

1. To introduce explicit, unique and intelligent examples regarding the application of the smart technology in design and construction of buildings. These would be used by students as design precedents which can be called and retrieved during the design process. It is also necessary to increase student's awareness about the smart technology. As students suggested, this is can be done by inviting specialists or practitioners to deliver lectures about the application of smart technology in building projects. Students should visit construction sites to see how smart devices and tools are implemented in buildings

2. To help students in understanding different types of the smart technology by interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining each type.

3. To help students in applying what they know about the technology so far in the design project through models, presentations or simulations. To guide students of which components of the technology would be applied and how they are going to be applied and how each application scenario would affect the design. Through this process, students should know that the technology is not a uniform solution for all types of users as users have different lifestyle in addition whether they are elderly, normal or disabled. Students should be taught how to address these differences while choosing various smart technology components and implementing it in design projects.

4. To assist students in analyzing process: by determining how the smart technology parts relate or interrelate to one another and how it works in harmony with the design concept and components. Students can illustrate this mental function by creating spreadsheets, surveys, charts, or diagrams, or graphic representations. These illustrations would highlight the positive effects on building components; users and building behaviour.

5. To help students in the creation process: teaching students how to put elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing. Creating requires users to put parts together in a new way or synthesize parts into something new and different form or design product.

6. To teach students how to evaluate solutions: making judgments through checking and critiquing. Tutors can ask students to make critiques, recommendations, and produce evaluation reports.

The above-mentioned methodology would not be successful if it does not consider the nature and the process of architectural design process. The development of a design concept is an interactive process through which the designer communicates ideas and would move forward and backwards during the development process. The designer repeatedly evaluates and alters the design and would change his/her mind and return back to the previous point or may be to the start point (Riba 1965[1], Markus 1969, Maver 1970, Lawson 2006). Lawson (2006) suggested that the design process is a simultaneous learning about the nature of the problem and the range of the possible solutions. Thus, the methodology for applying smart technology in design projects should not be viewed as steps in which one step leads to another but rather as a cycle of decision actions. Eventually, the smart technology should not be introduced in design studio sessions only but in theoretical courses across the College curriculum which would achieve the courses and academic program objectives and to ensure that students' capture the theoretical and technical sides of the technology.

{1} The RIBA handbook (1965) suggests that the design process may be divided into four phases:
Phase 1: assimilation in which general information specifically related to the problem is accumulated and ordered , Phase 2: general study in which the investigation of the nature of the problem, and the investigation of possible solutions or means of solution, Phase 3: development in which the development and refinement of one or more of the tentative solutions isolated during phase 2
Phase 4: communication which is the communication of one or more solutions to people inside or outside the design team
Markus (1969) and Maver (1970) developed the RIBA map, and they argued that a complete picture of design method requires both a "decision sequence" and a "design process" or "morphology". They suggested there is a need to go through the decision sequence of analysis, synthesis, appraisal and evaluation at increasingly detailed levels of the design (Lawson 2006)

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Appendix A

Table 1: Possible implementation of smart technology by students in design projects (Question 1)
Sample size of 64, **Bold font**: The percentages of students above 50% who voted for the chosen option

Smart technology components	I Do not know about it	It was not considered	It is taken into account but it had not applied	It was applied	Total it was not/difficult to consider	Total it possible to consider
Electronic medical Devices and medical aids	20%	27%	28%	25%	47%	**53%**
Energy management system (EMS) that includes lighting and heating control	6%	25%	36%	33%	31%	**69%**
Life safety System	14%	22%	25%	39%	36%	**64%**
Building electronic networking (i.e. Wired, Wireless)	6%	28%	31%	34%	34%	**65%**
Internet appliances: *Webcams, web phones, video walls etc*	11%	28%	39%	22%	39%	**61%**
Virtual clinic/hospital tools	23%	23%	36%	17%	46%	**53%**
Remote administration tools for monitoring and control of building systems	17%	36%	27%	20%	**53%**	47%
Voice recognition, movement tracking devices	31%	23%	28%	17%	**54%**	45%
Environmental Control Systems	20%	30%	23%	27%	50%	50%
Security and anti-burglary system	11%	31%	34%	23%	42%	57%
An individual wellness monitoring tools	28%	39%	22%	11%	**67%**	33%
Electronic equipment's aids for daily life	19%	36%	28%	17%	**55%**	45%
Tele-services through the Internet (e-grocery-services, e-banking, Telemedicine …)	22%	38%	25%	16%	**60%**	41%
Homecare facilities	25%	34%	22%	19%	**59%**	41%

Table 2: The type of effect of smart technology on building design as seen by students (Question 3)
Note: Sample size of 64, **Bold font**: The percentages of students above 50% who voted for the chosen option

Effect of the smart technology on the design of buildings	Increase	Neutral	Decrease
Flexibility of spaces in terms of the possibility of changing the use of internal spaces	59%	31%	10%
The designer ability to adapt spaces in terms of joining spaces or separation of spaces	53%	44%	3%
Complexity of designing the building facades	47%	42%	11%
The complexity of designing the elements of the building such as walls, door and windows	50%	30%	20%
The complexity of the building services such electricity, drainage, computer networking etc	58%	30%	12%
The building spaces in terms of adding up additional spaces such as control rooms	42%	39%	19%
Positively the conservation of energy of the building	69%	27%	4%
The improvement of the building security	78%	20%	2%
The possibility of incorporating adaptable fittings such as these in WC, Bath and kitchen	52%	45%	3%
The capability of spaces to accommodate new complex activities and ever changing technology	61%	39%	0%

Table 3: The links between student's views about the possible implementation of smart technology and their level of knowledge about it

Variables tested	Correlation value	Level of significance	Result
Possible implementation of energy management system * do not know how to implement it	0.35	0.05	Students who said they who do not know about it are those who do not how to implement it
Possible implementation of life safety system * do not know how to implement smart technology	0.44	0.01	Students who said they who do not know about it are those who do not how to implement it
Possible implementation of Virtual Clinic * do not know how to implement smart technology	0.37	0.03	Students who said they who do not know about it or not considered are those who do not how to implement it
Possible implementation of voice recognition movement tracking * do not know how to implement smart technology	0.36	0.04	Students who said they who do not know about it, or who said not considered, or who said considered but not applied are those who do not know how implement it

ادخال التقنيات الذكية كأداة استدامة في مشاريع التصميم المعماري لطلاب العمارة، جامعة الملك فيصل

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الملخص:

إن تبني مفهوم الاستدامة من قبل قطاع البناء في البلدان المتقدمة منذ عام ١٩٧٠ قد شجع على استمرار البحث واختراع التقنيات التي من شأنها أن تكون قادرة على ترجمة هذا المفهوم الى شكل عملي. إن أحد التقنيات التي اخترعت حتى الآن هي تقنية المباني الذكية التي تتألف من الأجهزة الإلكترونية والتي يمكن أخذها بعين الاعتبار في تصميم المبنى خلال مرحلة التصميم وتركيبها في وقت لاحق في هيكل المبنى أو التركيبات داخل المبنى خلال مرحلة الإنشاء. إن إدخال الأدوات الذكية من شأنه أن يساعد المستخدمين على إدارة الأمور المعيشية للبيئة الداخلية ويوفر بيئة مريحة ومستدامة. لم تؤثر تقنيات المباني الذكية فقط في تصميم المباني ولكن أيضا في كيفية فهم وحل مهندس التصميم لمشكلة التصميم المعماري.يجب على طلاب الهندسة المعمارية أن يكونوا مدركين لتقنيات المباني الذكية وكيفية تطبيقها في تصميم المشاريع حتى بصمموا مباني تستجيب بفعالية لاحتياجات المستخدم النهائي لأنهم –لاحقا- كمعماريين سوف يطبقون تقنيات المباني الذكية في التصميم المعماري. أجريت عملية مسح لتحري مدى معرفة الطلاب بهذه التقنيات في كلية العمارة والتخطيط، جامعة الملك فيصل، وأظهرت أن الطلاب يعرفون قليلا عن تقنيات المباني الذكية وكيف يمكن اعتبارها في عملية التصميم. تعرض هذه الورقة نتائج عملية المسح وتبين أسباب عدم معرفة الطلاب لهذه التقنيات. توصي الدراسة باتباع منهج يبين كيفية إدخال تقنيات المباني الذكية وتطبيقاتها في المناهج الدراسية المعمارية. هذا من شأنه رفع مستوى إدراك الطلاب للتقنية ويساعدهم في تطبيقها في مشاريعهم لخلق مشاريع تصميم مستدامة.