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Automated model for the sustainability of the educational physical infrastructure in Smart Cities

Juan José Bedolla Solano[1], Josemanuel Luna Nemecio[2], Adriana Miranda Esteban[3*], Ramón Bedolla Solano[4*]

[1]*Centro Universitario CIFE, Morelos, México; y, Tecnológico Nacional de México (TecNM) / Instituto Tecnológico de Acapulco (ITA). https://orcid.org/0000-0001-6999-8823*

[2]*Centro Universitario CIFE, Morelos, México. https://orcid.org/0000-0002-6850-3443*

[3]*Autonomous University of Guerrero, Mexico / School of Sociology. https://orcid.org/0000-0003-4313-6146*

[4]*Autonomous University of Guerrero, Mexico / School of Sociology and Regional Development Science Center (CCDR-UAGro). https://orcid.org/0000-0001-6219-4953*

**Correspondence authors: rabedsol@hotmail.com, mar86_05@hotmail.com*

Abstract:

Sustainability requires implementing strategies with actions that generate solutions for good living; being fundamental the development and evaluation of models and / or automated prototypes for their implantation in the institutions of the smart cities. Higher and postgraduate educational institutions are responsible for research, deepening attention to social problems to offer solutions that impact social, environmental and economic development. A strategic solution is the automation of the physical infrastructure, promoting the construction of automated models, with home automation, sustainable architecture, among other elements of engineering and technological innovation with a focus on environmental studies. The study contemplated mixed and applied research. The space design modeled with electronic resources, sustainable architecture, home automation engineering and software was presented and evaluated. It was proposed as a sustainable development strategy for its implementation in a physical infrastructure of the Technological Institute of Acapulco dependent on the National Technology of Mexico. The evaluation of the automated model determined the viability of implementing the prototype in the physical infrastructure as a feasible and sustainable strategic model for educational institutions in smart cities. Among the conclusions, the need to design technological development models and strategies for energy saving and resource safety for educational institutions in smart cities, which offer sustainable development alternatives focused on caring for the environment, is reflected., as a proposal for a sustainable model with the possibility of impacting technological development and engaging in multidisciplinary research on environmental issues.

Keywords: Smart space design, Sustainable development strategy, Sustainable model evaluation, Educational institutions, Smart cities.

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1. Introduction

Information and communication technologies (ICT) have evolved progressively based on innovation and development at a global level, this brings with it the rapid spread and dissemination of positive consequences in various sectors of society where the use of these tools in the organizations is closely related to process improvement and competitive advantage (Caraballoso et al., 2021). Technological progress has caused a profound change in social life, automatically sophisticating the orientation of massive technology processes (Ocaña et al., 2019).

Institutions supported by automated tools have implemented models with innovative technologies to improve processes; however, sustainability still needs to be considered in its entirety. Sustainability in educational institutions requires priority strategic studies focused on caring for the environment that address automation with home automation as a model term that contemplates the smart cities that manifest cities developed and currently applied for the optimization of resources using innovative technologies in living spaces; Gracia (2020) considers that these spaces must adapt to new technologies and even more so considering the emergency situation due to the Covid-19 pandemic. The urban space built in megalopolises is based on the construction of smart buildings, at the core of which is the automated management and control of electrical energy, control of lighting systems, security, air conditioning and monitoring of environments; coupled with this, the decrease in costs in sensors and communication devices (Marín-Rodríguez et al., 2021).

These buildings or infrastructures contemplated in smart cities have become an important research topic because different contexts and terms are conceptualized as there are different factors and needs that make them different (López et al., 2021).

The infrastructure of educational environments requires priority attention in which the aesthetic quality and conditions of users with a vision of sustainability are improved; contemplating educational policies that penetrate physical spaces will promote education with meaningful teaching and learning processes that go beyond their academic purposes. Education has been left in the background, when it comes to not improving the policies defined by the government to support educational institutions with respect to improving basic conditions and educational aesthetics (light, noise, ventilation), even more so there is a system that delays and complicates the investment of resources destined to improve the conditions of educational centers. It is evident that the quality of the infrastructure and aesthetics of schools and colleges have been relegated to public institutions such as banks, for example, where the aesthetics are far from that of educational centers (Quesada, 2019).

The National Development Plan 2019-2024 of the Federal Government of the Mexican Republic, establishes within its commitments, objectives and/or priorities for optimal development of the country. Within the National Development Plan, issues such as sustainable development and the use of science and technology for the benefit of human beings and the environment are addressed. The Mexican government is committed to promoting sustainability, which at the present time has been shown to be an essential factor for well-being. The dimension of sustainable development is an important issue and should be of interest to all, assuming the responsibility to commit through research and extension in order to design the future of itself and the society in which we are immersed, developing various tasks to preserve

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the environment and seek sustainability (Bedolla et al., 2021). This formula summarizes unavoidable ethical, social, environmental and economic mandates that must be applied in the present to guarantee a minimally habitable and harmonious future (DOF, 2020).

Currently, sustainability is a topic that is gaining more interest in companies around the world and especially in those of Mexico. However, it is important to highlight that it should not be seen as simple philanthropy, but as a new way of analyzing the organization's performance from four different and complementary perspectives: the economic one (related to the need for the company to be profitable in order to survive in time), the social (to address both internal and external impacts of this nature that the company's operations could present), the environmental (to take care of the impact that the company's operation could have on the environment and natural resources) and institutional (to promote its development as part of the business culture) (Carro et al., 2017).

The educational physical space is a common element to the whole of the student society. Investment in a factor that does not make exclusions, can mean a large-scale cultural development and have repercussions in the fight against growing inequality in recent years, aggravated by the socio-educational crisis. As a consequence of this, given the economic cost, the permanence over time of educational buildings and the need for rehabilitation and/or conservation projects for many of these, the learning space should be able to readjust to the needs of users and the teaching methodologies that emerge in much shorter intervals than the durability of these buildings (López, 2017).

According to Marín-Rodríguez et al., (2021) smart buildings as the material content of smart cities, have systems and facilities that allow their automated management and control, use various technologies, such as inmotics and the Internet of Things. Inmotics refers to home automation in buildings. Home automation is known as "the technical management of installations in homes that does not refer to buildings for non-residential use", which is why the term home automation comes, which can be said to be home automation in buildings. In this regard, the Spanish Standard EA0026 in collaboration with the Spanish Association of Domotics and Inmotics, establishes that inmotics encompasses the set of automation and control solutions through the use of techniques and technologies (electricity, electronics, computing, robotics and telecommunications), achieving better use, better resource management and control, oriented to hotels, town halls, museums, blocks of flats, buildings; regarding safety, comfort, management and communication; the difference that can be noticed with home automation is that it seeks more quality of life at home, while building automation seeks to obtain more quality of work.

The accelerated growth of the population and the unplanned urbanization processes have triggered environmental, social and economic problems such as the territoriality of COVID-19 that hinder the development of cities, and the quality of life of their inhabitants (Luna-Nemecio & Tobón, 2021). The smart city model seeks to solve the challenges of the contemporary city through interconnected intelligent systems, based on new information and communication technologies, achieving more efficient management of natural and economic resources. Many of the definitions endorsed by technology companies and, in turn, criticized by their detractors for being technocentric in nature, focus solely on the use of ICTs for data collection as support for city services. The most anthropocentric views, on the other hand, also

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consider social and economic factors from an integrated perspective, where the citizen is the center of development, thus extending the possibility of adapting this model to less developed cities that do not have the capacity to invest in technological systems. advanced (Copaja & Esponda, 2019).

The conceptual design methodology and automated systems for infrastructure modeling have been regularly oriented towards modernization and technological development with a sustainable strategy. The design of spaces developed through the analysis of resources, includes modeled systems that are evaluated to determine the feasibility of implementation and move towards sustainability. An urban space of this type considers innovative and competitive technologies; pointing out the efficiency of the project, the care of the environment and the reduction of economic expenses. The incorporation of automated tools is transcendental, since they contribute to carrying out the tasks and procedures carried out by human beings both in personal activities and in the business sector. Automatic systems facilitate and make procedures more efficient, contributing to the reduction of time and costs; as well as the increase in productivity and processes (Bedolla Solano et al., 2019).

The present study was oriented around the following purposes: 1) To determine the functionalities of the elements and electronic resources considered in software engineering and sustainable architecture for the design of intelligent spaces with home automation implementations in educational institutions of the smart cities; 2) Identify the environmental variables associated with energy saving and the evaluation criteria of the sustainable model for its implementation in a physical infrastructure; 3) Carry out an infrastructure design considering telecommunications with electronic resources and home automation engineering based on an analysis of resources, sustainable architecture and connection elements; 4) Address an environmental problem and security of resources that directly affect the environment and the economic expenses of the Technological Institute of Acapulco (ITA); 5) Submit a proposal with sustainable technologies that contribute to energy saving and that integrates a monitoring system for the control of users and resources of an area modeled with a strategic vision of contribution to environmental care and administrative control with wide possibilities of favorable impact on sustainable development and quality of life for the ITA community.

1.1. Literature review

The 2030 Agenda is the representation of the hegemonic discourse of sustainability that trivializes the complexity of the environmental crisis. Therefore, it does not represent a real option to achieve sustainability in effective terms. There is a little more than a decade left for the year 2030 and we can see how the Sustainable Development Goals (SDGs) are more than far from being met. To deal with climate change, factors that determine adaptation decisions are considered, where the critical characteristics that can be integrated into the formulation and implementation of policies to be integrated into a successful adaptation future are identified (Chandan -Kumar & Vijaya, 2021).

The generation of projects with inclusive and sustainable industrialization, together with innovation and infrastructure, can trigger and promote sustainable and competitive economic models that require infrastructure with innovative

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resources. The adaptation of spaces with innovative technologies focused on caring for the environment has repercussions in the reduction of the economic expenses of the institutions, at the same time in sustainable development. The use of a variety of devices to develop practical architecture and design of building environments based on the latest engineering approaches and technologies can provide new advanced intelligent applications for use in construction; therefore, they must meet the reliability and quality requirements that demonstrate a viable design advantage for smart construction (Kochovski & Stankovski, 2018). Research related to smart models are priority alternatives that contribute to these objectives and educational institutions rightly play a transcendental role in the development of smart cities.

There are several institutions that have comprehensively addressed the issue of sustainability, however, they have not had a significant impact on the most relevant problems of society. Technological tools such as information and communication technologies (ICT), but above all, Information Technologies for Communication and Knowledge for Digital Learning (TICCAD) (Luna-Nemecio, 2019) have been gradually integrated into the processes of knowledge transfer, for this reason research in relation to its favorable use to achieve the production of sustainable and resilient cities, as well as paying social participation in problem solving becomes relevant (Aguilar, 2017). Environmental and socio-environmental problems negatively impact and deteriorate the sustainability of communities, society, the environment, etc., it is necessary, the participation of all, government, society, organizations, institutions, etc., to contribute to the long-awaited sustainability (Bedolla-Solano et al., 2022).

The TICCAD are not alien to this reality and to a large extent have provided tools that precisely allow designing methods to reduce the impact on the environment. To tell the truth, they offer support in much of the activity of man no matter what it is. Although it is true that in past generations there was no genuine interest in preserving the planet, it is also true that there are more and more actions where projects are being carried out based on this particular type of technology to reduce damage to the planet. The TICCAD concept includes knowledge of work methods to satisfy needs or solve problems. It is a fact that automating work methods is where ICTs can add value, since they allow more exact results, reduce time, analyze possible scenarios, among other activities that will facilitate decision-making for those who need it. Fortunately, the use of TICCAD makes life easier for people, but it must be sustainable (Cornejo & Cornejo, 2018).

The smart cities have focused on various fields of research; in the academic field, the SmartCities phenomenon has been reconstructed to understand its meaning and applicability in the economic and political world, the identification of variables related to the development of social production and public value; in the databases of European cities classified as smart, in search of data and the way to communicate the smart actions taken for the benefit of citizens. A global and transversal approach is contemplated where the potential for growth and transformation of a city lies, including innovation, entrepreneurship and generation of economic activity , knowledge and talent that includes education with the existence of combined models and learning aimed at improvement and adjustments to the real demands of companies and society; and digital economy through programs, measures and actions to facilitate the approach to the digital world of the people furthest from new technologies, significant advances in digital public

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services and implementation of projects that promote the development of digital enterprises and programs specific attractions and digital talent in the city (Dariol, 2017). ICT and TICCAD incorporated in research contribute significantly to the projects of educational institutions, but they must focus on social needs, transforming spaces with sustainable models that transcend and promote the improvement of smart cities.

The educational physical infrastructure constitutes a fundamental space for the teaching-learning process, where the public service of education is provided by the State or by individuals with authorization or recognition of the official validity of studies. Furniture and real estate must meet the requirements of quality, safety, functionality, opportunity, equity, sustainability, resilience, relevance, comprehensiveness, accessibility, inclusiveness and hygiene, incorporating the benefits of the development of science and technological innovation, to provide education of excellence, with equity and inclusion (Solorzano, 2021). The physical infrastructure is a fundamental aspect for any higher level educational institution, in which the teaching-learning processes are specified. Therefore, the physical conditions of these educational spaces are essential for learning. For the qualification of the educational physical infrastructure in the countries, the executive architecture project is not enough, but rather it depends on the fulfillment of requirements established by regulatory institutions of each country (Rolón & Jiménez, 2019).

Sustainable architecture ("Emerging Paradigm of Complementarity for a Sustainable Architecture," 2020) sustainability in architecture requires a systemic approach, applied to the entire life cycle of buildings and the assessment of their behavior, using performance indicators. sustainability, which need to be measured quantitatively and qualitatively. It is important to determine variables and socio-environmental assessment criteria that have an impact on the sustainability of infrastructures when implementing smart homes in a smart city.

Energy saving, are all those ways of obtaining energy that produce a minimum or null ecological impact on the environment, during its extraction and generation processes (Rivasplata, 2019). Clean energy does not come from fossil fuels. It is argued that this subsumption of both terms is imprecise, among other reasons, because the exploitation of renewable energies also implies a set of negative socio-environmental impacts (Gutiérrez, 2020). The investigative work in educational institutions would have to visualize environmental proposals associated with energy saving with sustainable technologies to improve the quality of life.

In the study by Alvarado (2018); Principles and concepts that support the models of smart and sustainable cities and inclusive innovation are presented, identifying the regional location and comparison of the main smart and sustainable cities worldwide, giving priority to exposing the situation in Latin America, in particular Mexico. It is concluded that there is a need to create adequate environments, efficient and intensive use of available technologies, being necessary to accelerate the processes of learning, construction and accumulation of technological capacities as urban management strategies that allow social inclusion from the use and appropriation of technologies. TIC; as well as economic, social and environmental development to improve the quality of life and equality of citizenship.

Quintana et al., (2015) presents a design process for low-income housing based on the development of a low-resource automated system through home

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automation systems. Traditionally, these systems were designed and manufactured for groups with high purchasing power, without considering the environmental and social responsibility of their production and installation. In this study it was possible to identify all these factors that increase the cost, in order to establish the possibility of involving home automation projects in homes of the less favored population, in order to implement energy self-production technology for the design and manufacture of objects that contribute to the awareness of the energetic waste of the human being, and for another more fundamental, to the economic development in this group of social base.

In another of the works by García & González (2020), sustainable architecture is presented as a model for conceiving architectural design in a sustainable way and an energy-efficient lighting solution for a home. The use of home automation is also essential to achieve the purpose of saving energy while also offering comfort to its customers. This work presents a lighting control system dependent on natural lighting as a viable solution for sustainable housing supported by the system in the MATLAB ® Simulink ® program for total lighting control and implementation through the Arduino ® platform. The results achieved were validated from the energy point of view with the practical use of the designed system.

The references and works described above defined the theoretical bases to undertake the activities of the sustainable model designed based on the analysis of electronic resources, home automation aspects and the sustainable architecture of the space, which was presented as an infrastructure proposal modeled with design. intelligent and with a vision of sustainable development for the ITA educational institution. The aspects of technological engineering were identified, the socio-environmental variables in the design contemplated in the implementation of the educational infrastructure, the determination of a model designed with ICT and TICCAD for educational institutions of the smart cities and the dimensions of sustainability as an alternative to having an intelligent space design that contributes to energy saving and resource security that can be proposed as a sustainable development strategy to improve lifestyles; In addition to giving priority to multidisciplinary work for the care of the environment, which has an impact on technological, environmental, social and economic development.

2. Materials and method

2.1. Type of study

The methodology used for the development of the activities considered applied research, since it is intended to solve a certain problem or specific approach, enrich scientific development and consolidate knowledge for its application. Murillo (2008) points out that applied research is called practical or empirical; it is characterized because it seeks the application or use of the knowledge that is acquired and is closely linked to basic research, since it depends on the results and advances of the latter; this is clarified if we realize that all applied research requires a theoretical framework; however, in an empirical investigation, what interests the researcher, primarily, are the practical consequences; If an investigation involves both theoretical and practical problems, it is called mixed. In the study that is presented, techniques of software engineering, home automation and sustainable architecture were used to develop activities with automation of energy management, security of resources, comfort and well-being of the educational community of the career of Computer Systems Engineering and

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apply it in the design of the sustainable intelligent space model. In this work, mixed qualitative and quantitative research with a field approach was also contemplated; and documentary research that, according to Bedolla Solano et al., (2023), is periodically present in all the studies, due to the fact that the investigative analysis and study of art is carried out by reviewing research documentaries from various sources, whether electronic or from a certain place where the information is found.

2.2. Instruments

The survey instrument was designed and applied to determine the assessment and acceptance of a model in accordance with the modeled space that contemplates emerging information and communication technologies, and with a sustainable development strategy for its implementation. An interview with knowledgeable environmentalists was also designed and applied to find out their opinion regarding the development of the design and implementation of a sustainable prototype-model with innovative technologies for physical infrastructure of the educational institution that would contribute to caring for the environment. The combination, joint use or complementarity of the data collection techniques, in a certain way, is implicit in the methodological strategies and therefore in their triangulation process. The results obtained are subjected to a triangulation process, that is, to a process to contrast the data obtained as much as possible. In this way, the researcher can count on exhaustive and varied information for the understanding and interpretation of the situation under study. In qualitative research, the observer is the most important instrument for data collection; however, ICTs significantly increase both their observation skills and opportunities in the research process. (Orellana & Sanchez, 2006). Following the definitions indicated by Casas et al., (2002), the survey technique is widely used as a research procedure, since it allows obtaining and processing data quickly and efficiently; and considering other conceptualizations, it defines the survey as a technique that uses a set of standardized research procedures through which a series of data is collected and analyzed from a sample of cases representative of a broader population or universe, from which it is intended to explore. , describe, predict and/or explain a series of characteristics". For the work in question, a survey with closed questions was designed and applied to determine the feasibility of a prototype model designed with innovative technologies that would contribute to energy saving, resource security and environmental care. According to Troncoso & Amaya (2017), the interview is part of the qualitative task as an effective tool to unravel meanings; and indicating other definitions, the interview is the most used tool for data collection, since it allows obtaining data or information from the subject of study through oral interaction. In the work that is presented, the interview instrument was used to know the opinion mainly of knowledgeable environmentalists regarding the design, development and implementation of a prototype model as a feasible strategic proposal to be implemented in the physical infrastructure of educational institutions that impact on the dimensions of sustainable development.

2.3. Procedure

In the following methodological scheme and according to the purposes of the study, the systematization of stages or phases of development of the work carried out during the investigation is represented (figure 1).

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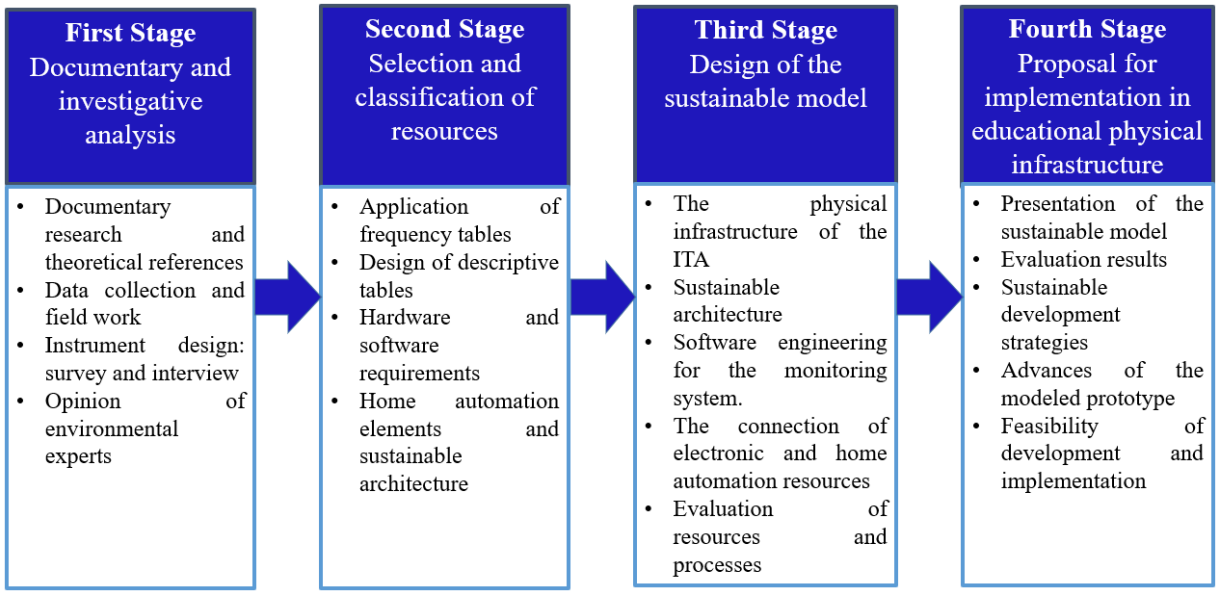

Figure 1. Stages of development of the research process: automated model for the sustainability of educational physical infrastructure in *Smart Cities*.

2.3.1. First stage. Documentary and investigative analysis

In this first stage of development of the study, a documentary investigation was carried out; For this, the information of the documents stored on the website of the educational institution, the Institutional Plan for Innovation and Development of the ITA and the National Development Plan of the Federal Government were reviewed; in addition to carrying out the investigation of the conceptualizations and theoretical references related to the study in question. To carry out the data collection, the survey and interview instruments were designed, which were applied to a sample of students, teachers and managers of the educational institution; Key informants with environmental knowledge from both the ITA and other educational institutions and the government of the Municipality of Acapulco, Guerrero, were also considered. The field work also contemplated observation, through which it was possible to identify aspects related to infrastructure, security, and aspects of environmental impact.

2.3.2. Second stage. Selection and classification of resources

In the second stage, the classification of the information collected was carried out through documentary and investigative analysis. The survey data was classified through frequency tables, measurement instruments that allow data to be ordered according to characteristics considered in the sample. The information from the key informants was also classified, which contemplated a brainstorming of the entire group to which the interview was applied. The purpose was to organize the opinions and suggestions; and from this, carry out the discussion of the inquiry to select relevant or interesting information and generate creativity with new ideas to undertake methods and designs with alternative solutions. Descriptive tables were designed to identify the various elements to be considered in the

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sustainable model, such as electronic resources, elements of software engineering, home automation engineering and elements of sustainable architecture. In this instrument the characteristics, functionalities, applications, advantages and disadvantages were described. The treatment of the descriptive tables also made it possible to identify the hardware and software engineering requirements, among other aspects and elements of home automation for modeling spaces with automation.

2.3.3. Third stage. Design of the sustainable model

The third stage contemplated the modeling of the physical space considering various aspects and elements of home automation engineering, sustainable architecture and software engineering. The sustainable modeling work began with the registration of the strengthening project for the research working group: Technology and Sustainability, with key ITACA-CA-6., which was ruled favorably during the call for academic bodies. 2018. Among the aspects and elements considered was the physical infrastructure; For this, the necessary and administrative procedures were carried out before the ITA authorities to obtain a classroom-type space in the 700's building that belongs to the Computer Systems Engineering career, which could be modeled as a development strategy. sustainable for the educational institution. In the design of the modeled space, aspects of energy saving were considered as one of the actions of environmental care and economic impact. In addition to a monitoring system, based on software engineering and the connection of electronic and home automation resources for intelligent spaces, in order to control access and security of resources. The modeled design contemplated various disciplines that visualize the conclusion of large multidisciplinary and sustainable projects.

2.3.4. Fourth Stage. Proposal for the implementation of a model-prototype in educational physical infrastructure

The fourth stage of the study, which considered the design of the sustainable model, was supported by the analysis and the results obtained through the evaluation carried out through the measurement instruments. In this stage, various schemes were generated with designs focused on aspects of sustainable architecture, home automation and software engineering. The comprehensive sustainable model was also generated in order to be presented as a proposal for sustainable technological development to both students and decision-makers of the institution. For environmental connoisseurs, it was presented as an environmental care strategy and as a feasibility project to be implemented in educational institutions in the Acapulco region. The evaluations carried out regarding the model, in addition to the functionalities of some aspects and resources for this proposal, have promoted the progress of the work to undertake the implementation of this sustainable model that is already focused as a prototype. In the classroom-type space, implementation work began, such as sustainable architecture, the monitoring system and implementation of some electronic and telecommunications resources. In this study, resources have been managed through calls for funded research to present a strategic prototype of sustainable development for educational institutions.

With the world's growing need for energy and the dwindling availability of energy resources, a wide range of interactive visualizations are being developed to enable people to use energy more efficiently by monitoring their consumption patterns and identifying possible potentials to

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support any behavior change and that these visualizations achieve their goal. The behavior change model that defines three factors of motivation, trigger and skill was used. A survey showed that most existing interactive visualizations target the motivating factor with some trigger or supporting skill and only a few address all three factors of the behavior change model (Rist & Masoodian, 2019).

Table 1 describes the evaluation criteria of the sustainable automated model designed and presented as a viable proposal for the physical infrastructure of the ITA educational institution, as well as the indicators of the evaluation aspects considered to carry out the measurements contemplated in the instruments. of surveys and interviews.

Table 1. Criteria and indicators of the evaluation aspects of the sustainable model with home automation and software engineering for educational physical infrastructure in smart cities.

Evaluation criteria of the sustainable model for the ITA	**Indicators of the aspects and/or evaluation criteria of the proposed sustainable model for its implementation in a physical infrastructure of the 700's building belonging to the Computer Systems Engineering career**
Analysis of resources and elements for the modeling of sustainable technological projects	• Knowledge of the PND, the PIID and issues regarding sustainable development projects. • Knowledge of the SGA and impact actions on environmental aspects. • Promotion and promotion of strategic values for the care of the environment. • Automation and existence of processes for the care of the environment.
Infrastructure design for the development of smart sustainable models	• Knowledge of project designs with automation for the care of the environment in the ITA infrastructure. • Knowledge and environmental education with technological development in the ITA infrastructure. • Knowledge of the environmental dimensions for sustainable development at ITA. • Knowledge of energy saving management, security of resources and other aspects with automation to reduce economic spending in the ITA.
Feasibility of development and implementation of smart sustainable models	• Feasibility of implementing environmental actions or programs with emerging technologies in the ITA. • Ease of resource management to implement sustainable technological projects at ITA/TecNM.

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in educational institutions of smart cities	• Participation of the ITA in projects and research with a focus on sustainable technological development. • Feasibility of implementing sustainable models that impact environmental, economic and social development.

The sample considered to assess the automated sustainable model designed for the physical infrastructure of the ITA, in which a total of 456 respondents participated: 393 students from the ISC educational program with collaboration in research projects or those who took the subject of sustainable development (DS), 26 ITA professors who have taught the subject of SD or who have collaborated or participated in research projects, 17 ITA decision-makers or knowledgeable about administrative control procedures; They were also considered in this survey and in the interview with 20 knowledgeable environmentalists from other institutions in the municipality of Acapulco, Guerrero, Mexico.

Table 2 shows the statistical data obtained from the sample considered in the automated sustainable model designed for the physical infrastructure of the ITA, where it can be seen that 315 of the respondents are men, representing 69.07%, and 30.92% are women. ; It is also noted that 86.18% of the respondents are classified in the student subgroup, while the subgroup of ITA teachers has 5.70%, ITA directors 3.73% and environmental connoisseurs represent 4.38% of the respondents. . It can also be seen that 80.70% of the respondents are people between the ages of 15 and 25, corresponding to the subgroup of students. The arithmetic mean regarding the ages of the respondents is 25 years, the most repeated age was 20 years and the standard deviation of the respondents is 9.13 years.

Table 2. General and statistical data of participants surveyed in the evaluation of the automated sustainable model designed for the physical infrastructure of the ITA.

Grouping	Subgroup	Frequency	Percentage	Half	fashion	Median	Standard deviation
Gender	Men	315	69.07%	25	21	22	9.45
	Women	141	30.92%	24	21	21	8.35
Profile	Students	393	86.18%	21.58	21	21	3.23
	ITA Masters	26	5.70%	48.54	42	48.5	9.55
	ITA directors	17	3.73%	46.76	43	45	6.18
	Environmental connoisseurs	20	4.38%	36.95	37	37.5	7.12
Age	15 to 25 years	368	80.70%	20	20	20	2.02
	26 to 35 years	30	6.58%	28	26	28	2.54

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	36 to 45 years	30	6.58%	41	42	41	2.47
	46 to 55 years	21	4.61%	51	53	51	2.96
	More than 56 years	7	1.54%	60	56	56	4.62
Total		456	100%	25	20	22	9.13

3. Results

The results consider that the analysis of elements and electronic resources supported by conceptual references generate automated solutions for the modeling of sustainable spaces that contemplate innovation, since individuals appropriate the functionalities of emerging technologies, developing models or prototypes with a vision of sustainable approach. Technological appropriation is based on the development of a digital culture supported by ICT and TICCAD. In this sense, Giraldo et al., (2018) consider that, in order to achieve technological appropriation in cities, the available technology must be adapted and transformed to solve problems or satisfy specific needs of a community. For his part, (Rosenberger, 2019) defines it as the result of access, understanding and adoption of a certain technology in everyday processes.

Figure 2 presents the design of the physical space, modeled based on software engineering, home automation and smart cities. This design was developed based on the considerations of sustainable architecture, where an architectural plan suitable for the materials and dimensions of the educational physical infrastructure is outlined, which was considered as a final prototype proposal evaluated for its possible implementation.

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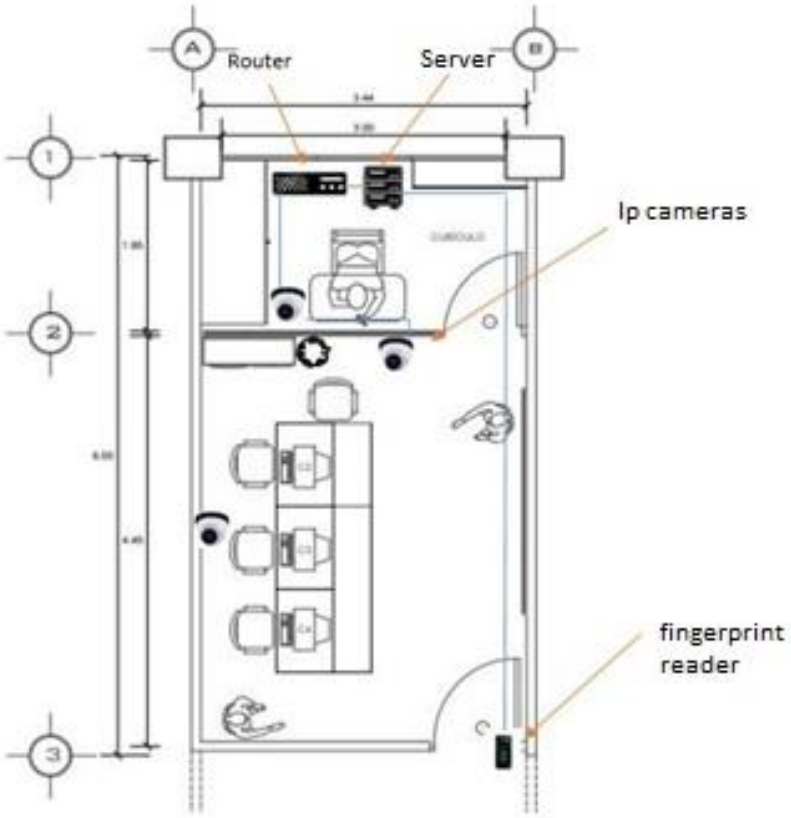

Figure 2. Smart space design with home automation implementations and sustainable architecture in the ITA infrastructure and proposal for smart educational institutions cities.

The scheme represented in Figure 3 was generated by the Database Management System, applying the data modeling techniques considered in software engineering. This scheme represents the relationship between entities or logical objects, where the connection of the information that is carried out through the monitoring system will be made.

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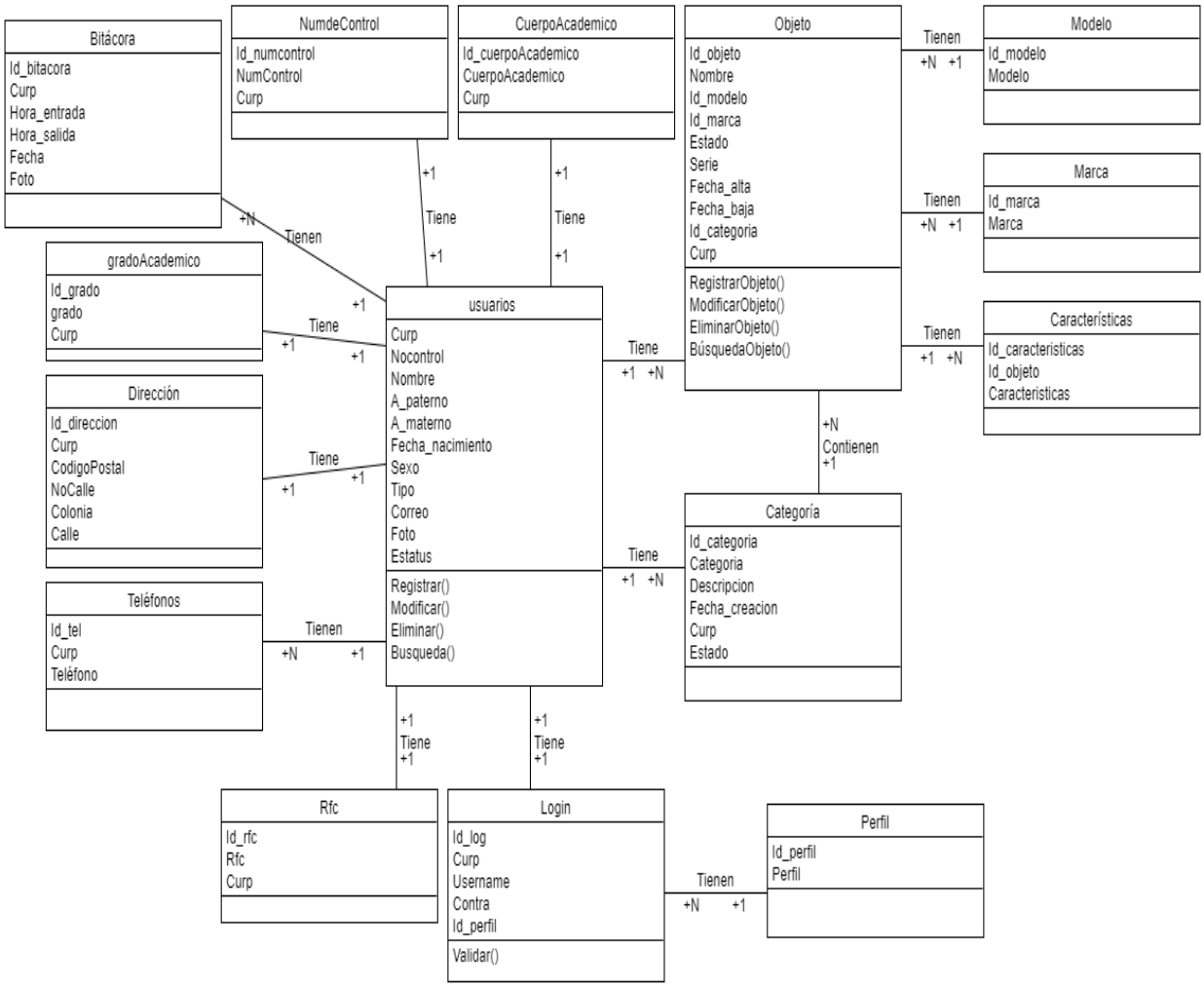

Figure 3. Software engineering database model for the control of users and electronic resources of the modeled area with a vision of environmental care and administrative control contemplated in the design of the automated space for the physical infrastructure of the ITA.

Figure 4 shows the connection diagram for access control and resource registration, through which security is implemented. This design was generated based on the description of the elements and electronic resources for smart designs with home automation engineering and sustainable architecture. The connection defined in this diagram was established between the monitoring system implemented on a server that links to the security cameras.

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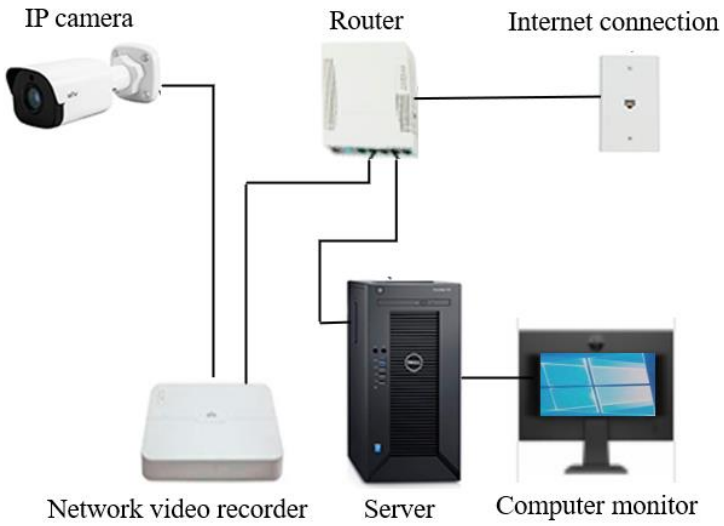

Figure 4. Connection diagram with electronic resources determining the functionalities of the intelligent space of the ITA educational institution, generated based on ICT, TICCAD, smart cities and sustainable home automation implementations considered in the automated model.

Figure 5 presents the results related to the evaluation of the analysis aspect of resources and elements for the modeling of sustainable technological projects. For the knowledge indicator of the PND, the PIID and topics regarding sustainable development projects, it determined 115 favorable responses that are equivalent to 25%; Regarding knowledge of the EMS and actions with an impact on environmental aspects, it generated 216 favorable responses, which is equivalent to 47 %. The indicator promotion and promotion of strategic values for the care of the environment, the result reflected 192 favorable responses, which is equivalent to 42% of the total number of respondents, although the result is perceived as a minimum, it can be considered important because environmental problems are already addressed. The automation and existence of processes for the care of the environment, the result of the survey reflected 179 favorable responses, which is equivalent to 39%. The analysis of resources and elements for the modeling of sustainable technological projects identified elementary knowledge that must be considered in the design of these projects because it allows knowing, selecting requirements and optimal aspects to apply during development; in addition to making the best decisions; therefore, the intelligent space model that is presented for the physical infrastructure of the ITA educational institution with a contribution to energy saving, environmental care and administrative control has ample possibilities of being implemented as a sustainable development strategy because it will directly address the environmental problem, economic expenses and quality of life of the community of the Technological Institute of Acapulco.

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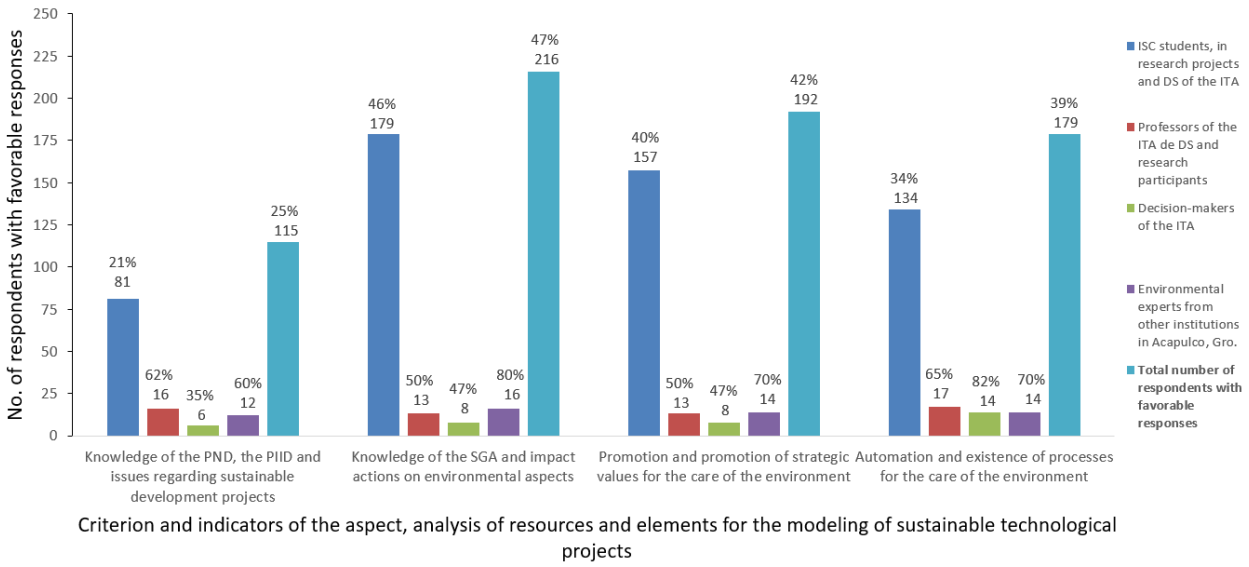

Figure 5. Graph of the results of the evaluation of the aspect analysis of resources and elements for the modeling of sustainable technological projects; survey developed during the periods August-December 2020 and January-June 2021 to students, professors and directors of ITA, and environmental experts from other institutions in Acapulco, Gro. Mexico.

Figure 6 presents the results of the evaluation of the design aspect of infrastructures for the development of intelligent sustainable models. In the indicator knowledge of project designs with automation for the care of the environment in the ITA infrastructure, 231 favorable responses were obtained, equivalent to 51%; For the environmental knowledge and education indicator with technological development in the ITA infrastructure, 199 favorable responses were obtained, equivalent to 44%; Regarding the knowledge of the environmental dimensions for sustainable development in the ITA, the result reflected 392 favorable responses, which is equivalent to 86% of the total number of respondents; and for the indicator of knowledge of energy saving management, security of resources and other aspects with automation for the reduction of economic expenses in the ITA, the evaluation reflected as a result of the survey 297 favorable responses, which is equivalent to 65 %; therefore, the design of the intelligent space model that is proposed to be implemented in the physical infrastructure of the ITA educational institution points out automation as an important aspect for caring for the environment by managing energy savings and security of the resources that must be integrate into projects and/or sustainable technological developments that manage knowledge and are applied in the dimensions of sustainable development; In addition, to point out aspects to optimize processes and minimize the economic expenses of the institutions. The result for this evaluated aspect is low; however, the contribution of engineering with automated design with a sustainable approach contributes in an important way for educational institutions, since it manages and promotes knowledge of models developed with technology and innovation that meet the dimensions of sustainable development that are necessary to be implemented in the smart cities.

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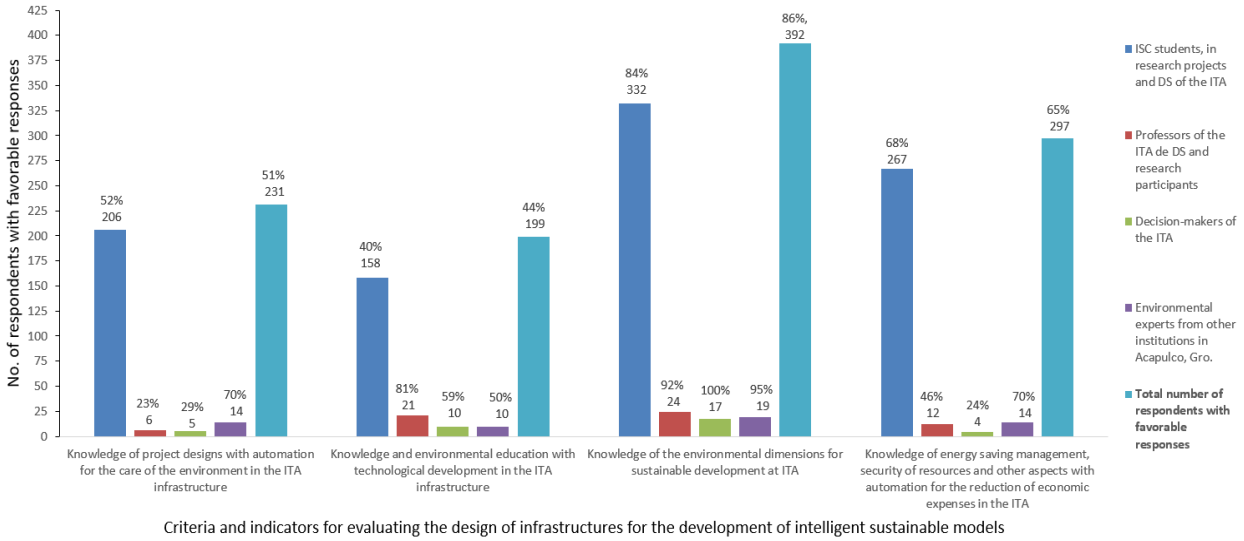

Figure 6. Graph of the results of the evaluation of the infrastructure design aspect for the development of sustainable smart models at ITA, Gro. Mexico.

Figure 7 presents the results of the evaluation of the feasibility aspect of development and implementation of intelligent sustainable models. The feasibility of implementing environmental actions or programs with emerging technologies in the ITA is determined with 178 favorable responses equivalent to 39%; The ease of resource management indicator to implement sustainable technological projects at ITA/TecNM determined 231 favorable responses, which is equivalent to 51%; Regarding the participation of the ITA in projects and research with a focus on sustainable technological development, the result reflected 108 favorable responses, which is equivalent to 23% of the total number of respondents; Finally, the feasibility of implementing sustainable models that have an impact on environmental, economic and social development reflected 233 favorable responses, which is equivalent to 51%. Therefore, the evaluation of the sustainable intelligent space model determines viability and feasibility to be implemented in the physical infrastructure of the ITA educational institution. On the other hand, participation in the development of these projects is expanded through applied scientific research and insertion in smart cities that the globalized world demands. Finally, the management of resources is opened through calls promoted by state and federal government agencies and institutions.

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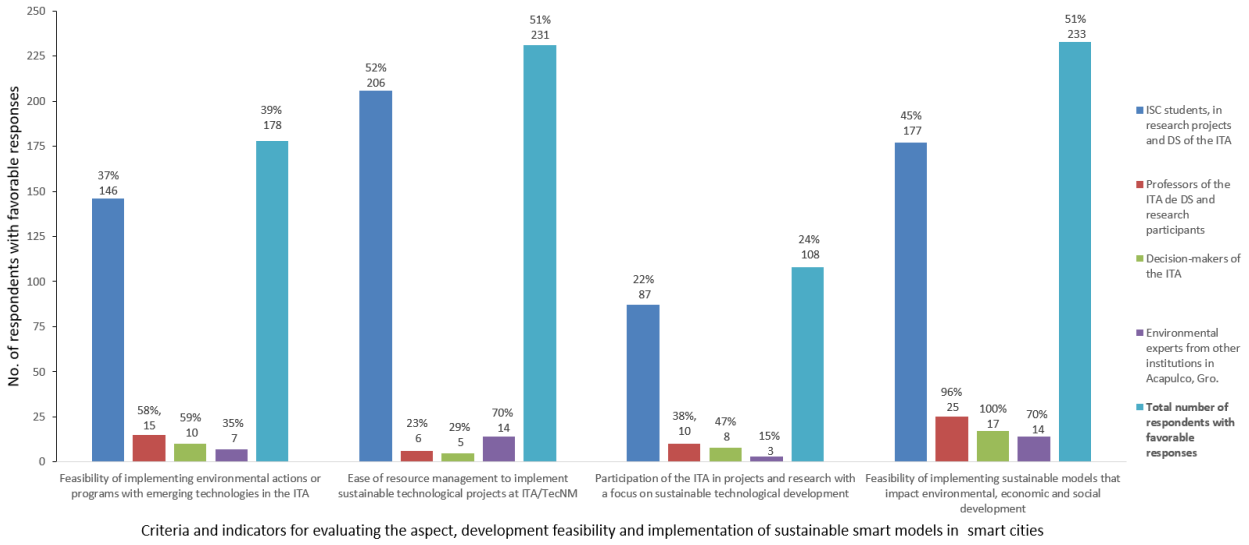

Figure 7. Graph of results of the evaluation of the feasibility aspect of development and implementation of intelligent sustainable models in the ITA, Gro. Mexico.

4. Discussion

The sustainable automated model developed based on the analysis of electronic resources and elements of home automation engineering and software supported by telecommunications and the Internet network, contemplates a strategic design-prototype that could be implemented in the physical infrastructure of the ITA and consequently a sustainable development proposal (model-prototype) with innovative technologies for the educational institutions of the National Technological Institute of Mexico. The analysis of the resources through descriptive tables made it possible to determine the specifications and to be able to use these elements that would define the intelligent space model with greater precision. According to Fernández et al., (2020) the Internet of Things (IoT) has emerged as an important research area that combines environmental sensing and machine learning capabilities to flourish the concept of smart spaces, in which intelligent and personalized services can be provided to users in an intelligent way. In smart spaces, a fundamental service that must be provided is the precise and discreet identification of the user. But even greater, the analysis of electronic resources and elements in an investigation such as the model of automated spaces with a vision of sustainability, will determine the certainty and conclusion of the projects.

The study and development of sustainable projects with innovative technologies is a priority mainly in educational institutions as they are considered strategic research proposals aimed at sustainability (Bedolla Solano et al., 2020). In this sense, the automated model with innovative technological systems for physical infrastructure opens up important possibilities to meet priority requirements of institutions and achieve sustainability in smart cities. The monitoring system modeled for the security and control of resources for a physical infrastructure, determines the importance of automation, data processing, storage and control of information in a safe and efficient manner. Therefore, "the one supported by

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Luo et al., (2020) regarding the service for the discreet identification of the user in intelligent spaces" in which they seek to explain the importance of identification before using an intelligent space, these authors explain that the use of any intelligent space for the use in which it is used must be used with great care, since they explain that they are very valuable. For their part, Rocha et al., (2021) considers that solving the planning of energy demand achieves a compromise between energy cost and user comfort in smart spaces.

The development of sustainable and multidisciplinary projects with emerging information and communication technologies; they lead to the generation of comprehensive and complete works, because diverse needs and heterogeneous areas of work are contemplated by researchers, as is the case of the model of sustainable intelligent space that is presented for educational institutions. The use of the internet in smart spaces is fundamental; in these smart spaces, it is sought that they be developed in universities, mainly those that are located in the smart cities. Advances in technology and data analysis provide rich opportunities to develop smart environments that help their inhabitants, the so-called smart environments or smart spaces; enhanced with technology, sensors, user interfaces, and various applications, these smart spaces are capable of recognizing users and the situations they find themselves in, reacting accordingly, for example, by providing certain services or changes in the environment itself (Gilman et al., 2020).

The feasibility of the design and development to implement the sustainable automated model in the physical infrastructure of the ITA leads to energy savings, the safety of resources and the comfort of the institute's community, by integrating innovative technologies. It also contributes to the dimensions of sustainable development with economic, social and environmental impact. In this sense, Hang & Kim (2018) consider that a practical predictive control system based on improved models to maintain indoor thermal comfort, which includes a multiple linear regression predictive model and an innovative fuzzy controller that considers both the voting rate predicted medium (PMV) as the conditions of the external environment. To verify the usability of the designed system, a prototype of an Internet of Things (IoT) intelligent space was chosen and experimentally tested in a building. The verification of this usability complements the assessment of the aspects and evaluation criteria of the sustainable model that is presented as a strategic proposal for sustainable development that contributes to energy saving, environmental care and administrative control for the ITA educational institution.

5. Conclusion

The analysis of electronic resources, elements and aspects of home automation, and software; It has allowed modeling a space of the educational infrastructure in a safer and more efficient way. In this space with automation, various designs were developed with a vision of sustainable strategy. Engineering aspects were also considered considering ICT, TICCAD and sustainable development that contemplates sustainable architecture, energy saving and technological innovation that encompasses process automation and intelligent software engineering systems.

In the process of modeling the space, measurements of the automation, home automation, sustainable architecture, security and environmental aspects were considered. These considerations made it possible to disseminate

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knowledge of the contribution of energy savings, comfort and safety of resources in an infrastructure modeled with a sustainable strategy and therefore the environmental and economic impact on the ITA educational community. The results of this assessment generated satisfactory deductions regarding the design and implementation of the proposed model, obtaining an acceptance percentage of 67.25%.

Environmental connoisseurs consider that the development of sustainable strategies that are carried out in public institutions of the higher and postgraduate level, promoting research, already address a priority problem that must be taken into account urgently. It is also considered that collaborative work with multidisciplinary processes leads to the development and completion of large projects in educational institutions, mainly those located in smart schools cities; and the objectives established in the PND are met, regarding the development of sustainable technological projects, leading to the fulfillment of the goals and indicators of the proposed projects.

The proposal of this sustainable model and the satisfactory result of the measurements carried out gave rise to the beginning of the first works and advances in the implementation of strategic actions focused on sustainable development for the ITA. This modeled design for a classroom-type architectural space generated an initial prototype of sustainable technological development for the infrastructure of the 700's building that belongs to the Computer Systems Engineering career of the Technological Institute of Acapulco.

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