UNIVERSITÀ DELLA CALABRIA

Dipartimento di Fisica

Scuola di Dottorato
"Archimede" in Scienze, Comunicazione e Tecnologie

Indirizzo:
Scienze e Tecnologie dei Sistemi Complessi

Con il contributo della

Secretaría Nacional de Educación Superior, Ciencia, Tecnología e Innovación (SENESCYT - ECUADOR)

XXVIII CICLO

TITOLO TESI

THE "SMART GALAPAGOS ISLANDS":
The design of a Learning Platform for Digital Economy, Fun, Innovation and, Education

Settore Scientifico Disciplinare

M-PSI/01

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Dedicated to God, my loving and wonderful parents Pedro Vaca y Elvita Cárdenas, my sisters and brothers, my sister in law and my little niece for always being my inspiration. Their words of encouragement and support during this journey gave me the tenacity to accomplish it. May God bless all of them.

Declaration

I hereby declare that except where specific reference is made to the work of others, the contents of this dissertation are original and have not been submitted in whole or in part for consideration for any other degree or qualification, or to any other university. This dissertation is my own work and contains nothing which is the outcome of work done in collaboration with others, except as specified in the text and Acknowledgments. This dissertation contains fewer than 63000 words including a bibliography, appendices, tables and has fewer than 126 figures.

Leticia Azucena Vaca Cárdenas
November 2016

Acknowledgements

I would like to express my gratitude to God and all those individuals and institutions who have supported and helped me during my doctoral studies.

Firstly, my sincere gratitude and recognition to my advisor Prof. Eleonora Bilotta for her continuous support during this Ph.D. and for her invaluable guidance throughout these years.

Besides my advisor, I would like to thank also to Prof. Pietro Pantano, Director of the Doctoral School, for his opportune insightful comments.

To my sponsor, the Secretary of Higher Education, Science, Technology and Innovation (SENESCYT) of Ecuador for the finances granted to my studies and research.

To the Evolutionary System Group of the University of Calabria ESG (Cube 17/B) my research team, who shared this journey with me.

Many thanks to:

Dr. Janna Fallin, Director of the Teaching & Learning Center and University Distinguished Teaching Scholar at the Kansas State University (KSU) of U.S.A., who provided me an opportunity to join her team as an intern. Her faith, professionalism, experience and continuous encouragement inspired me.

Dr. Michael Raine, Director of Information Technology Projects and Services at KSU and Dr. Roger McHaney, University Distinguished Teaching Scholar, Director of the Management Information Systems of the College of Business Administration at KSU, for permitting me to have a successful research period abroad as a scholar visitor.

Heartfelt thanks to the Vaca Cárdenas family for their prayers, great love, full support, timely advice words and their absolute confidence in me.

Last but not least, thanks a million to all the friends that I met here at the UNICAL, abroad and those from home, for the moral sustain and affection that I have always received from them.

"To speak gratitude is courteous and pleasant,
to enact gratitude is generous and noble,
but to live gratitude is to touch Heaven".
- Johannes A. Gaertner -

Abstract

The analysis and description of complex systems in all scientific fields are becoming increasingly significant. Complex systems are composed of many interconnected and mutually interacting parts, with highly unpredictable behaviors as outcome [49]. The multidisciplinary study of complex systems over the last years has led to introduction of new significant conceptual perspectives and methodologies for challenging social and global problems in the 21st-century. Education, in this view, can be considered a complex system that should be adapted according to the new society requirements [175].

Nowadays, the great evolution of Information and Communication Technologies (ICTs) has forced to reconsider the principles, methodologies, tools, and training in the educational field. In fact, several studies have shown how students learn more effectively when learning is participative and interactive. Teachers, meanwhile, have increased their interest towards these educational systems because of the potential and unique characteristics that they possess.

To explore the complexity of today's educational systems, an advanced learning platform called "The Smart Galápagos Islands", to be used by teachers, learners and researchers has been designed, as main goal, in this research.

The design of the system included the following steps:

- Analysis of users requirements through:
  - A first experimentation with pre-service teachers
    - To introduce coding as a powerful tool
    - To make pre-service teachers not only digital users but also digital makers.
    - To development the Computational Thinking (CT) Skills, and,
    - To improve the Team Work Competency (TWC)
  - A survey applied to Business teachers in order to validate the ICT skills and uses in an IoT classroom and,
  - The collaboration in the study on regards to Big Data over SmartGrid - A Fog Computing Perspective.

- Development of the components of the system:
  - The Serious game in Scratch of Darwin's journey to discover biological evolution
  - Creation of the different 3D virtual environments in the Galápagos Islands, and
  - The website, first design.

The theory of reference in regards to the studies carried out, according to different educational and scientific perspectives, is constructivism. It is also linked to the opportunities provided by Open Technology, Contamination Lab concept, and STEAM (Science, Technology, Engineering, Arts and Mathematics) education, focused in "Do-it-Yourself" (DiY) and Co-working approaches.

Results showed that is highly significant to explore and encourage the process of integrating cutting-edge technology and paradigms as ICT and IoT into teaching-learning practices and their emerging challenges in different stages in this digital age.

Sommario

L'analisi e la descrizione dei sistemi complessi stanno diventando sempre più significative in ogni branca della scienza. I sistemi complessi sono composti da diverse parti interconnesse e mutuamente interattive, il cui risultato è una serie di comportamenti altamente non prevedibili [49]. Lo studio multidisciplinare dei sistemi complessi negli ultimi anni ha portato all'introduzione di nuove e importanti prospettive e metodologie concettuali per affrontare problemi sociali e globali del 21esimo secolo. L'istruzione, in questo quadro, può essere considerata un sistema complesso che ha bisogno di essere adattato alle nuove necessità della società [175].

Al giorno d'oggi, la grande evoluzione delle Information and Communication Technologies (ICTs) ha dovuto riconsiderare i principi, le metodologie, gli strumenti e la formazione nel campo educativo. In fatti, diversi studi hanno dimostrato come gli studenti imparino in maniera più efficace quando l'apprendimento è partecipativo e interattivo. Allo stesso tempo, l'interesse degli insegnanti nei confronti di tali sistemi educativi è aumentato grazie al potenziale e alle caratteristiche peculiari che possiedono.

Per esplorare la complessità degli attuali sistemi educativi, il principale obiettivo di questa ricerca è stato la progettazione di una piattaforma avanzata per l'apprendimento chiamata "The Smart Galápagos Islands", per insegnanti, studenti e ricercatori.

La progettazione del sistema ha incluso i seguenti steps:

- Analisi delle necessità dell'utente attraverso:
  - Una prima sperimentazione con insegnanti Pre-service
    - Per introdurre la programmazione come strumento importante.
    - Per rendere gli insegnanti in formazione dei creatori digitali oltre che degli utenti digitali.
    - Per sviluppare le Computational Thinking (CT) Skills, e,
    - Per migliorare la Team Work Competency (TWC)
  - Un'indagine applicata a insegnanti di Economia Aziendale allo scopo di validare le ICT skills e i loro usi all'interno di una classe "Internet of Things" (IoT) e,
  - La collaborazione allo studio relativo ai Big Data over Smart Grid - A Fog Computing Perspective.

- Sviluppo delle componenti del sistema:
  - Il Serious game in Scratch sul viaggio di Darwin alla scoperta dell'evoluzione biologica.
  - La creazione dei diversi ambienti virtuali 3D nelle isole Galápagos, e
  - Una prima progettazione del sito web.

La teoria di riferimento relativamente agli studi svolti, secondo diverse prospettive educative e scientifiche, è il costruttivismo. È inoltre legata alle opportunità offerte dalla Open Technology, dal concetto di Contamination Lab, e dall'istruzione STEAM (Science, Technology, Engineering, Arts and Mathematics), incentrata sul "Do-it-Yourself" (DiY) e gli approcci di Co-working.

I risultati hanno dimostrato che è molto significativo esplorare e incoraggiare il processo di integrazione di tecnologie all'avanguardia e di paradigmi quali l'ICT e l'IoT all'interno delle pratiche di insegnamento-apprendimento, così come le relative sfide emergenti a diversi livelli in quest'era digitale.

Resumen

El análisis y la descripción de los sistemas complejos en todos los campos científicos se están convirtiendo cada vez más importantes. Los sistemas complejos están compuestos de muchas partes interconectadas y mutuamente interactivas, con comportamientos altamente impredecibles como resultado [49]. El estudio multidisciplinario de los sistemas complejos en los últimos años ha conducido a la introducción de nuevas significativas perspectivas conceptuales y metodologías para desafiar los problemas sociales y globales en el siglo XXI. La educación, desde este punto de vista, puede considerarse un sistema complejo que debe adaptarse de acuerdo con los requisitos de la nueva sociedad [175].

Hoy en día, la gran evolución de las Tecnologías de la Información y la Comunicación (TICs) han obligado a reconsiderar los principios, metodologías, herramientas y la formación en el ámbito educativo. En efecto, varios estudios han demostrado cómo los estudiantes aprenden más eficazmente cuando el aprendizaje es participativo e interactivo. Los profesores, por su parte, han incrementado su interés hacia estos sistemas educativos debido a las características potenciales y únicas que poseen.

Para explorar la complejidad de los sistemas educativos de hoy en día, se ha diseñado, como objetivo principal de ésta investigación, una plataforma de aprendizaje avanzado llamada "Las Islas Galápagos Inteligentes", para ser utilizada por maestros, estudiantes e investigadores.

El diseño del sistema incluyó las siguientes etapas:

- Análisis de los requerimientos de los usuarios mediante:
  - Una primera experimentación con maestros en formación para
    - Introducir la programación como una herramienta poderosa
    - Hacer de los profesores en formación no sólo usuarios digitales, sino también creadores digitales.
    - Desarrollar las habilidades de pensamiento computacional (CT) y,
    - Mejorar la Competencia del Trabajo en Equipo (TWC).
  - Una encuesta aplicada a Profesores de Administración de Empresas para validar las destrezas y usos de las TICs en un aula dotada de un sistema de Internet de las cosas (IoT) y,

  - La colaboración en el estudio con respecto a Big Data sobre Smart Grid – Una perspectiva de Computación en la Niebla (Fog Computing).

- Desarrollo de componentes del sistema:
  - El juego serio en Scratch del viaje de Darwin para descubrir la teoría de la evolución
  - Creación de los diferentes ambientes virtuales tridimensionales en las Islas Galápagos, y
  - El primer diseño del sitio web

La teoría de referencia en relación con los estudios realizados según diferentes perspectivas educativas y científicas es el Constructivismo, vinculado también a las oportunidades que ofrece la tecnología abierta, el concepto de educación STEAM y los enfoques “Hágalo usted mismo" (DiY) y trabajo cooperativo y colaborativo.

Los resultados han demostrado que es muy importante explorar y fomentar el proceso de integración de la tecnología y paradigmas de vanguardia como TICs e IoT en las prácticas de enseñanza-aprendizaje así como también los desafíos que emergen en diferentes etapas in esta era digital.

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Chapter 1

Introduction

"Technology can become the'wings'that will allow the educational world to fly father and faster than ever before-if we will allow it"

Jenny Arledge

"We need technology in every classroom and in every student and teacher's hands, because it is the pen and paper of our time, and it is the lens through which we experience much of our world." – David Warlick

1.1 Background

The analysis and description of complex systems in all scientific fields are becoming increasingly significant. Complex systems are composed of many interconnected and mutually interacting parts, with highly unpredictable behaviors as outcome [49]. The multidisciplinary study of complex systems over the last years has led to introduction of new significant conceptual perspectives and methodologies for challenging social and global problems in the 21st-century. Education, in this view, can be considered a complex system that should be adapted according to the new society requirements [175].

In the past, for instance, Ecuadorian education has been based on teaching and learning processes developed in other countries.

When I started my academic career as a teacher, I was still a university student, When I got my degree, I had the opportunity of working with people of different levels, from elementary schools until higher education level, but most of that time I spent in the "Amelia Gallegos" High School, and I am pretty sure that this experience changed my life forever.

It is a public educational institution, three years ago it had one thousand and two hundred students and seventy-two teachers.

There, I completed different roles, if you are a teacher you should be able to run so many roles at the same time especially in an underdeveloped country. As a computer science teacher I was able to use and implement with 3 others professors and with the scarce resources two laboratories, the “new” one was assigned for bachelor students from 15 to 17 years old and the other one for courses that were part still of the basic education from 12 to 14 years old students. In every single class, one computer was shared by 5 of 6 students in the best cases and the most important issue is that the computer laboratory was the only place where most of them could access to a computer. In Ecuador, the education was not a priority, but the things during the last 7 years have radically changed.

Today, Ecuador is looking stability and becoming more diverse, the country wants to go away from oil and develop new priority sectors, such as tourism and education. The history says, in the past, education of quality was affordable only for wealthy people, even though this is changing, still exists a big breach amongst rich and poor [72].

Improving access to quality education is a government priority in its political plan; as a result, a number of reforms were funded and implemented to reach these goals. First of all, a new constitution was created in 2008, Sustained by over 65% of Ecuadoreans (Consejo Nacional Electoral, 2008), whose results augmented the decision-making power of the government represented by the president, authorizing him to take decisions in regards to several many concerns, inclusive social matters, in order to get fundamental transformations. In the educational sector, the constitution validated the Ten-Year Education Plan and aims and it has had wide-range impacts in this area. (http://educacion.gob.ec/).

According to the national constitution, the educational system should be controlled by the state and its entities and it was confirmed that education spending should be expanded to six per cent of Gross Domestic Product GDP. The document mandated universal access to education as well as mandatory enrollment in initial, basic and secondary education, or its equivalent (Art. 27 of the Constitution). It further underlined that public education must incorporate the country’s interculturality, should be free up to and including undergraduate level. Changes were institutionalized in 2011 with the passing of the Organic Law on Intercultural Education [194] [72]

The priorities for the new higher education law were to increment equality and enhance quality. Until few years ago, the higher education sector was highly privatized, becoming education into a business; for this reason, to face quality issues, the government started closing down private institutions that do not meet accreditation standards. The scholarship and accreditation institution of the Ecuadorian government, Secretaría Nacional de Educación

Superior, Ciencia, Tecnología e Innovación (SENESCYT), after a selection process offers diverse scholarships for students, professionals and teachers in different areas to study abroad in ranking universities as well as funding for returning and visiting academics [194], [72], (http://programasbecas.educacionsuperior.gob.ec/).

During my time in the High School, I noticed the lack concerning the use of ICT at schools, a big problem for both students and teachers. To get the infrastructure was a key goal, there were diverse opinions from teachers, students, politicians, Information Technology (IT) managers and so on. This raised discussions for or against such infrastructure. At the time, the institutions were forced to survive with tight budgets, so technology was each time a simple target for reduces [110].

In one hand the lack of infrastructure and on the other hand, the national curriculum had stated that schools were encouraged to use technology in order to teach students the skills of the 21st-century, this was one disagreement. Another divergence was that not all teachers or headmasters were inclined to use Information and Communication Technology (ICT) in class even if it was available [110]. The third discrepancy was that the use of technology at school did not seem to alter or enhance the pedagogical tools that teachers were using. The teachers, meanwhile, have increased interest towards these educational systems because of the potential and unique characteristics of them, but unfortunately also encounter difficulty in accessing, expanding and adapting these platforms with their content.

At Europe level, the Survey of Schools on regards to ICT in education was carried out in 2011-2013 in 31 countries by the European Commission in order to get information about access, use and position of ICT in schools in the EU27 [298].

Results showed that a high number of teachers have common relation with ICT for teaching and learning for few years, however, they use it in a principal way to prepare their teaching. Solely some teachers use ICT throughout classes and to have a relationship with parents or to set the students' tasks at home as a new type of feedback. Foundings report that the total prevalence of ICT-based activities during lessons is on average about several times a month [281].

On average at EU level, students reported undertook ICT-based activities only several times a month and never or almost never. Digital resources are almost never used by participants in the class. It is more frequent the use of ICTs at home than in classrooms.

More than 20 years ago, Don Tapscott, a highly recognized innovator of the world, explained how the digital revolution that he called Digital Economy, enables new models of global problem solving, cooperation and governance [267].

Governments and education policy makers must act faster to help people to make greater use of the Internet and remove regulatory barriers to digital innovation or else risk missing out on the potentially huge economic and social benefits of the digital economy [226].

In the Digital Economy, the focus is based on the human capital, translated into "knowledge". It is the driver, with knowledge comes power and a way to change lives for the better through newer opportunities.

Consequently, in this currently approach one of the key sectors is the learning and education, where the convergence and enhance of computing, communications and multimedia content can make possible a quality education. In the Digital Economy the most important factor is the human resource, here, people have to be willing to change and to transform themselves in new leaders [266], [108], [270]

Survival in a digital economy world demands higher-level cognitive skills for understanding, interpreting, analyzing and communicating complex information and these are everyday ICT skills.

In this way having into account this particular background from the global world, in particular from Europe, Italy and Ecuador and knowing that the great development of the ICT has forced to a reconsideration and reconstruction of the principles, methodologies, tools, and training in educational field, and being clear that new advanced teaching-learning systems can be designed, implemented and developed by Ecuadorian people and they could be part of the world globalized educational system. An advanced learning platform called "The Smart Galápagos Islands", to be used by teachers, learners and researchers in interactive environments, has been designed in this research. "The Smart Galápagos Islands" have a Future Internet (FI) core platform, for educational purposes and open interfaces. This stratified environment contains different options, and each one can be used according to different educational and scientific perspectives; users will be able to interact with this environment online. In this view, learners using the platform will approach the "Future Internet", and the encouragement through the different studies for the realization of wares or applications (App). The theory of reference is constructivism, linked also to the opportunities provided by Open Technology, Contamination Lab concept, Do it Yourself (DiY) and Co-working approaches.

This complete study was aimed to exploring the process of integrating ICT and IoT into teaching-learning practices and their emerging challenges in different stages.

This complete research work has followed the design -based research approach, whose protocols require intensive and medium and long-term collaboration and combines the promotion of alternative answers to pragmatical issues in educational conditions [162].

In this research, a mixed design (quantitative & qualitative) process was applied helped by several programming software according to the scientific method used in each study carried out. Additionally, a web platform was designed in order to present the main results and applications designed and developed during this complete research journey.

The innovation of this research is presented in each study of the designed system and their direct connection with the development of the 21st-century skills required in a digital age with a Digital Economy, in this case "Enconomy" means a community of people adding value to each other's work, improving the quality and availability of educational software, applications, tools or materials.

The platform and applications were designed thanks mainly to the next software:

- Unity 3D for the Galápagos Islands 3D environments and locations. Unity works with the next programming languages:
  - C# (C Sharp): Based in the .Net Platform;
  - Javascript: To made shorts, quick and practical scripts;
  - Boo: It is and implementation of Python.
- iClone;
- 3ds Max;
- Adobe Photoshop;
- Adobe Illustrator;
- PubCoder;
- Free Make Video Converter;
- Scratch: For the Game of Darwin and the coding study with pre-service teachers
- HTML and PHP for developing the web site;
- SQL for the Data Base;
- PowToon;
- Prezi

For the Stadistic process and data analysis of the different surveys of this research the next software was used:

Google Forms; Qualtrics; Microsof Excel;

1.2 Research scope and Goal

Technology advances are forcing institutions to change their schemes and models in order to fit new challenges for education, due to the huge amount of available data, the exponential growth of knowledge and the consequent increase of competitiveness in the work area. Education has now to rethink its own models and become an active and participative process, fully in touch with a lot of resources and with the needs of today's students, that is what the "Smart Galápagos Islands" Platform for Digital Economy, Fun, Innovation and Education wants to offer.

This system could allow the adaptation of Ecuador educational system to high international standards through its purpose of globalization. Moreover, its implementation can provide numerous products and services. Its realization could also favor the Digital Economy process in Ecuador, the increasing of job positions for developers and researchers, and could also be connected to the creation of new business of young people.

Special policies and actions at infrastructure scale are still needed to enable the most students, at all levels, to be in highly digitally equipped schools. Such policies are urgent in some underdevelopment countries. Infrastructure-related policies should be accompanied by complementary measures in other areas and particularly in teacher professional development for the use of this infrastructure [281].

The main goal of this research was the design of an advanced learning platform called "Smart Galápagos Islands" Platform for Digital Economy, Fun, Innovation and Education, linked to the different surveys applied in this research to be used by teachers and learners in interactive environments. Taking into account the STEAM (Science, Technology, Engineering, and Art) education and the development of Computational Thinking Skills, 21st Century Skills, the use of Information and Communication Technologies, and the Internet of Things paradigm.

Hypothesis or research question:

Is "The Smart Galápagos Islands" web platform for digital economy, fun, innovation an education able to provide teachers, students and researchers alternatives and suggestions for teaching and learning in a digital economy world applying the STEAM education approach, following the 21st Century Skills with an IoT approach, based on the ICT use?.

Results

- Apply the Digital Economy approach

- Use of the ICTs as tools for sustainable development and introduce the new IoT paradigm.
- Promote the society of information
- Wide participation of the stakeholders of education
- To implement technological infrastructure
- Promotion of tools for the inclusion of digital solidarity

1.3 Thesis outline

The research is structured as follows. The first chapter presents a summary of the main motivations and the background of this research from a global point of view. The second chapter emphasizes the approach of the digital economy and its close relationship with ICTs as a fundamental part of its development. In the 21st century, "knowledge" is the most important key to the development of people in society.

The third chapter discusses the Internet evolution from the beginning and how it permits education arrives to everyone and everywhere in different ways and especially through MOOCs (Massive Open Online Courses).

The fourth chapter reviews the new trend, the Internet of Things and the challenges in current society. The "Smart" age is here.

The fifth chapter has an overview of the importance of Computer Science at schools, having into account the 21st-century skills, STEAM education, project-based-learning, Edutainment, games in education, Computational Thinking skills development through coding, hands-on activities and Do it Yourself (DiY) approach.

In sixth and seventh chapters the several works and surveys carried out during this research are presented, starting with the Coding lessons for Pre-service teachers in order to introduce coding as a powerful tool, to promote de Scratch use, to developed the Computational Skills, to get digital makers and to improve the team Work Competency, the survey applied to Bussines faculty in order to validate the ICT Skills in an IoT classroom and the survey on regards to the Fog Computing and Smart Grid in an IoT paradigm followed by the digital components of the system the edutainments developed in 3D and the applications in Scratch in 2D.

Finally, general conclusions of the work accomplished are presented and aditionally unsolved problems and recommendations for future exploration are outlined.

Chapter 2

Digital Economy and The Information and Communication Technology (ICT)

"Modern technology has become a total phenomenon for civilization, the defining force of a new social order in which efficiency is no longer an option but a necessity imposed on all human activity"

Jacques Ellul

2.1 Introduction to the Digital Economy and ICT

The rising acceptance and utilization of information and communication technologies (ICTs) facilitate the digitalization of economies and societies, with the wide use of the internet for digital services as e-commerce, e-health and e-government and e-education. Currently, in accordance with the Organization for Economic Cooperation and Development (OECD) countries, for each four people, three of them have an internet subscription for a daily use, around to 95% of companies are online, three-quarters have just online information and nearly half of them, use this web platforms to do e-commerce [226], [229]. The OECD started in 1960 when 18 European countries joined the United States and Canada to create an organization dedicated to economic development, the organization currently has 35 members around the world including most advanced countries and also emerging countries (http://www.oecd.org).

Entire economies are becoming into digital economies and it will enhance thanks to the current paradigm of the "smart objects" by the approach of the Internet of Things (IoT) [229]. Due to it, the generation of a phenomenal quantity of data called as "Big Data" will be unavoidable, its analysis will be essential to management and ensure a transformation across technology [226], [229].

People with the high-end skills needed to invent, use and apply new technologies are in high demand over the world. Digital economies are powered by skills. In addition, in this century, the basic skills needed to navigate technology-rich environments (ICT) effectively in our connected community has expanded.

Nowadays, Information and Communication Technologies (ICTs) have transformed society. In this modern age, information is power; hence, the management of such information is through the use of ICTs [5].

The widely accessible ICT devices in the last decade have changed the perspective of higher education. Many have claimed that these technological changes will dramatically alter both business models and pedagogical models in higher education [164].

The great evolution of the ICT affects directly the form in which people, interact, socialize and work. ICT skills and knowledge have been considered as the core literacy which students need to possess for the 21st century [85]. Therefore, ICT suggests both new approaches for learning and new forms of interaction, changing the relationships in the classroom [129], [22].

ICT can also be used to promote the use of new methods of teaching and learning (student-centered methods) which includes among others collaborative and cooperative learning, peer group, problem-solving, etc., to consider a few [129], [6].

The future education system requires reinstatement because the world is changing constantly, higher education cannot be out of this process, the issue is to know the purpose of a college [193].

Further, as noted in the European Commission's communication 'Rethinking Education' (2012), the improvement of education and training frameworks is imperative to accomplishing upper productiveness and the provision of exceedingly skilled people [254].

In this context, it invited countries to: "revise and strengthen the professional profile of all teaching professions (by) reviewing the effectiveness as well as the academic and pedagogical quality of Initial Teacher Education, introducing coherent and adequately resourced systems for recruitment, selection, induction and professional development of teaching staff based on clearly defined competences needed at each stage of a teaching career, and increasing teacher digital competence"(European Commission 2012a) [254].

2.2 Digital Economy definition

Definition 2.1 *The term "Digital Economy" was coined by Don Tapscott in 1995 in his best-seller "The Digital Economy: Promise and Peril in the Age of Networked Intelligence". The Digital Economy was among the first books to show how the Internet would change the way we did business [266].*

Digital Economy can be defined simply as an economy founded on digital computing technologies. Digital Economy is the worldwide network of economic activities enabled by information and communications technologies (ICT) [266].

The digital economy is also called the Internet Economy, the New Economy, or Web Economy (https://en.wikipedia.org/wiki/Digital_economy).

Don Tapscott is President of Trent University in Peterborough, Ontario and adjunct professor at the Rotman School of Business at the University of Toronto. He is highly considered, he was named in 2013, one of the top five business thinkers in the world by Thinkers 50, an award compared as an Oscar of Management Thinking. Thinkers 50, has three "core beliefs":

- Ideas have the power to change the world;
- Management is essential to human affairs;
- New thinking can create a better future.

The Digital Economy of Don Tapscott is, heretofore, the most significant contribution to make widely popular those convictions. He has advocated open cities, calling for new ways of thinking to face and solve current problems of big cities. He has statements about "economic development, public safety, transportation, energy, clean air and water, human services, education, food security, and democracy" [108].

Tapscott expressed:

"Today's digital networks enable all citizens to be aware of what is going on in the city and be able to contribute their ideas to the way they are governed. To achieve social cohesion, good government and shared norms, the new realities demand a second wave of democracy based on a culture of public deliberation and active citizenship. This is not direct democracy: it is about a new model of citizen engagement and politics appropriate for the 21st-century".

Source: Tapscott, The Digital Economy Anniversary Edition: Rethinking Promise and Peril in the Age of Networked Intelligence New York, N.Y.: McGraw-Hill, 2014.

2.3 Digital Economy Characteristics

Tapscott in his book "The Digital Economy" described twelve characteristics of the "New Economy" given a prediction of the today' world, these are [266], [270].

1. **Knowledge:** The focus of digital economy is placed on the human capital, expressed into knowledge. It is the conductor, with wisdom arrives authority and a form to shift lifestyle in a better way looking and generating novel possibilities. In other words, access and the possibility to use information to afford many different alternatives or choices for users.

2. **Digitization:** Information is exhibited in digital form, in binary (0,1), and amenable afforded by digital equipment, it enables the sharing and use of an enormous quantity of information, today well known as big data in brief time between people wherever they are on the planet.

3. **Virtualization:** It is highly probable to transform palpable objects into virtual displayed by environments developed by the digital information managed. This gives a new approach to the social interaction and of course to the business movement.

4. **Molecularization:** Conventional company forms are becoming more fluid thanks to flexible teams with personal from different places on the world, changing strictly ordered frameworks. In the Digital Economy the 'light organization' will survive to the static 'heavy organizations' that will die eventually.

5. **Integration/Internetworking:** Digital Economy is an economy that integrates small parts into big components that interact each other and with others, until creating a network for wealth getting. All the stakeholders will should to share, collaborate and coordinate in order to subsist.

6. **Disintermediation:** Middleman functions are being removed, if business or organizations want to survive they require to keep working in the digital way. Businesses are by the time linked with their users by technology facilities and interchange data between providers and clients, novel forms of aggregating excellence could be established.

7. **Convergence:** The confluence of computer science, communications and information are creating the commanding business area. The new trends are platforms which integrate all these resources in a digital way.

8. **Innovation:** Digital Economy is built on innovation through the development and utilization of ICTs with the aim to create novel results on regards to services and products. People's imagination and action translated into creativity are the principal resources to fostering innovation.

9. **Prosumption:** In this times of networked intelligence, where the ICTs enable clients or users to be part or know the complete process of production, the clue point currently is mass production according to customers' requirements.

10. **Immediacy:** Users are well informed. The interval time among the request of a merchandise and its production and distribution is extremely more shorter than ever before, due to the ICT.

11. **Globalization:** Certainly, with knowledge as a key resource a global economy could exist due to the contemporary revolution in the ICTs.

12. **Discordance:** With the technological phenomenon, the breach amongst people who has and people who do not have access to technology is increasing and it could bring meaningful issues to citizens in coming times.

The characteristics above described are bringing the possibility of novice ways of the business establishment, taking advantage of the new ICTs for a knowledgeable work. In this way, organizations will grow in efficacy and production capacity. To get this transformation follow the next steps: [266], [270].

- The effective individual: an effectiveness person who use her or his own computer and digital resources;

- The high-performance team: people working together effectively within an organism, using ICT tools to improve and restructure the business process;

- The integrated enterprise: where the whole personnel of an enterprise is tied showing a great organizational change with the use of ICTs;

- The extended enterprise is an enterprise tied to its clients or users and/or producers to offer articles or services adapted to user requirements in an extraordinary and competent manner answering new requirements; and

- The internet-worked business: Here a business connects "online" with other providers and organisms on a highly resilient base in order to make or built better and quality products for users, appears the internet-worked team for specific products or services, according to the needs and market dictates. Here also the growth of the ICTs and the ‘net’ allow this type of improvement.

2.4 Principal Technological Shifts for the Digital Economy

This transition process should be accomplished through ten “technological shifts” identified by Tapscott, in order to face the ever-changing requirements of the society.

- *From analog to digital:* it means, the use of ICT for information management having all data in a digital form.
- *From semiconductor to microprocessor technology:* high-speed processing and large quantity. Technology indeed will be more accessible in cost and usability.
- *From host to client/server computing:* these novel architectonics devices permit to access, share and process through networks into different computers, they may be clients or servers.
- *From "garden path" bandwidth to information highway:* an unbelievable advantage in the way of data carriage and sharing.
- *From dumb access device to information devices:* interactive digital devices on and off for the information highway, now, well known as "smart devices".
- *From separate data types to multimedia:* whole communications are enabled through interactive multimedia.
- *From proprietary to open systems:* software applications will be multiplatform and compatibles.
- *From dumb to intelligent networks:* Tapscott was talking about ’knowbots’ or software systems that could do repeated tasks automatically, based on the user searches.
- *From craft to object computing:* the new world demands each time more portable applications. Starts the object-oriented computing era with software adaptable to the user’s requirements and with friendly interfaces.
- *From GUIs to MUIs, MOLEs, MUDs, MOOs and Virtual Reality:* novel interactive 3D virtual worlds to get virtual experiences, using Multimedia User Interfaces (MUIs), Multi-User Domains (MUDs), Object-Oriented MUDs (MOOs), and Virtual Reality (VR).

The connotation and the use of all this new technology impact important areas of the society, such as::

- healthcare
- retailing and distribution
- design and manufacturing
- public relations
- government
- leisure, travel and tourism
- **learning and education**
- publishing, entertainment and the new media industry

The main changes are due to reducing costs, improving efficiency, adding value, eliminating disintermediation (consumers are directly in contact with producers), reducing the time and the convergence and enhance of computing, communications, and multimedia content. To make it possible, the most important factor is the human resource, people have to be prepared to progress [266], [108], [270].

Tapscott, 2014 manifested: “The digital revolution enables cities to better integrate social services, reducing cost and improving value”.

A wise guidance can facilitate positive changes and the acceptance of a "digital economy". Tapscott detected six commands on regards to leadership, here a summary of them:

- Accomplish an internetworked leadership is an own decision. Everybody can be part of it and actively collaborate.
- The correct direction in the digital economy is "leadership for learning". Everybody is able to collaborate in making decisions in the organization as a whole.
- Internetworked leadership is a collective leadership. "The intellectual power generated through networking minds for collective vision will far surpass the intellectual prowess of the smartest boss" (p.252).
- Internetworked leadership can be digital. The leadership is not only a role for one person, everyone in the organization with knowledge can contribute in taking main decisions.

- Internetworked leadership is incomplete without the support of the Chief Executive Officer (CEO). The CEO's participation is vital for the organization metamorphosis.

- Individual management of the ICTs makes leaders. In the organization, people have to be familiar with basic ICT.

Digital economy enable open access to big data and promotes knowledge transfer to everyone and everywhere. However, still exist big problems to manage and these are 1) "privacy and security" and 2) the growing breach betwixt digital literates – the "haves" and the "have-nots". This conception obtained from Tapscott regarding to rank wealth founded on knowledge production is genial, however, it is absolutely proved now and it is still not accepted by many people in the society.

In Fig. 2.1 it is possible to have a snapshot of the concerns of the digital economy on 1994 and the potential or problems after 20 years.

2.5 Potential of the Digital Economy

It is well known that the digital economy has not yet reached its full potential. In Digital Economy is extremely important to take advantage and to have an outlook of the digital world. Going digital can bring countries closer to sustained prosperity [226].

The manufacturing and services of the ICTs global trade continue growing. Enterprises are investing in Research and Development (R&D), besides the recent increment in patents on regards to ICT shows the key role in innovation that the ICT sector has [226].

The expanding broadband markets and the increment in wireless broadband subscriptions show the decreasing in fixed telephony. The networks communication performance is improving with the deployment of fibre and 4G, 5G, the prices, specially for mobile services are reducing [226].

According to the OECD, it is necessary:

- To expand coverage and improve the quality of fixed and mobile broadband infrastructures it will allow progressing towards the ***Internet of Things (IoT).***

- Thanks to the growing demand on networks and more spectrum resources, the complementarity of fixed and mobile networks will need to be exploited in an efficient manner.

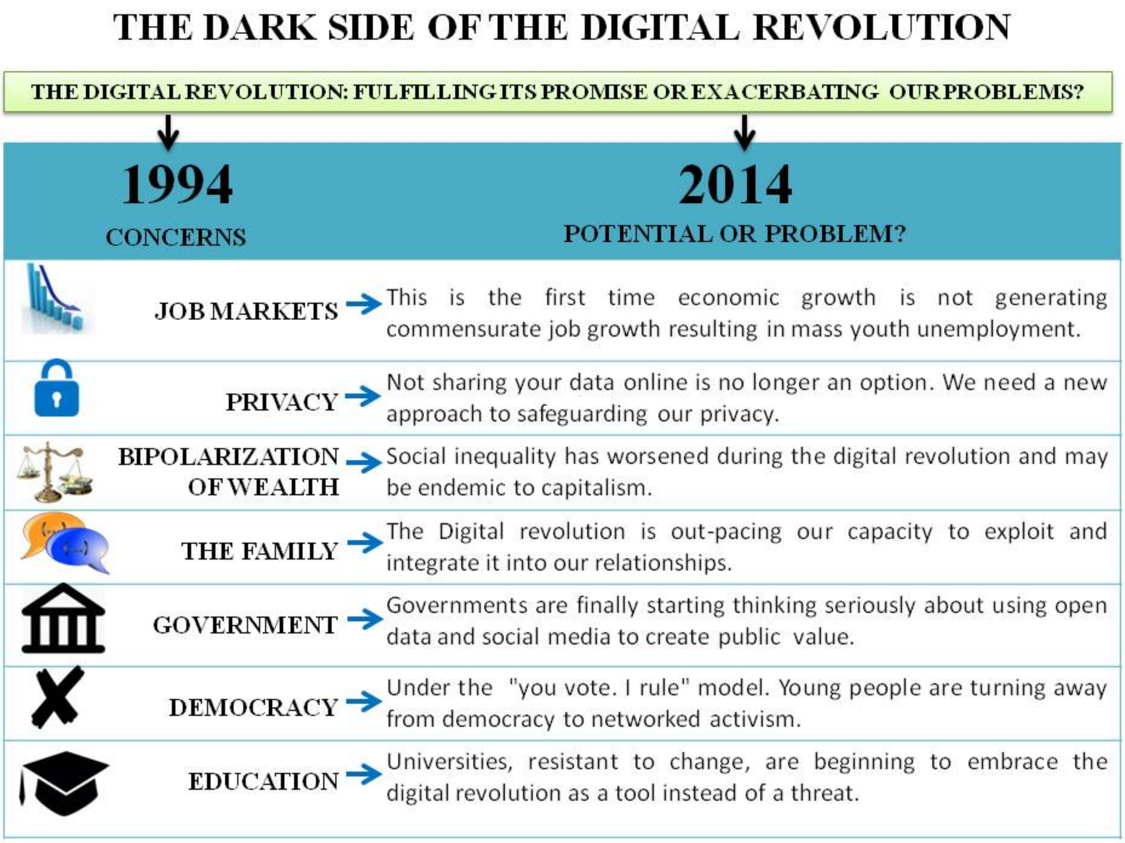


Fig. 2.1 Don Tapscott's The Digital Economy, 20 years on. New analysis of how the internet has changed business and society in the last 20 years.
Source: The Digital Economy Anniversary Edition: Rethinking Promise and Peril in the Age of Networked Intelligence New York, N.Y.: McGraw-Hill, 2014.

- Exist a huge potential for passing and using ICTs and the Internet to propel expansion, development, and innovation in all sectors. Statistics show that 95% of all enterprises with more than 10 employees in 2014 have an internet connection, few use enterprise resource planning software (31%), cloud computing services (22%) or receive electronic orders (21%). Differences remain considerably among countries and between small and large companies [226], [227].

- Collaborative production methods are the new business models, for instance, platforms for crowdfunding and new "sharing economy" are challenging founded markets and requesting for policy reply that allows innovation keeping the public interest.

- The approach for better acceptance is also important for individuals. Users represent the key factor of each area. Notwithstanding wide diffusion, intensity of Internet usage continues to oscillate, singularly for activities such as e-government, e-commerce, and online banking, associated with a higher level of education.

2.5.1 Internet Governance and ICT Policy Required

The importance of Internet policy making and Internet governance among stakeholders of the international community has increased with the pervasiveness growing of ICTs and the Internet across countries' economies [226], [228].

The future Internet governance is being evaluated. A proposal to transition United States Government surveillance of the Internet Assigned Numbers Authority (IANA) to the international Internet community was presented, but, the General Assembly of the Internet Governance Forum (IGF), a multi-stakeholder platform that manages policy issues on regards to the Internet, on December of 2015, confirmed the extraordinary development of the Internet and ICTs in last years during the evaluation of the results of the World Summit on the Information Society (WSIS+10). For this reason resolved to prolong for 10 more years the prevailing agreement with the IGF. This organism will also maintain and control the attempts to accomplish the Sustainable Development Goals (SDGs), which are related particularly to the Internet and ICTs [226], [171].

The United Nations will release the post-2015 development agenda, setting sustainable promotion goals, which are including access to ICTs and the Internet to create an expansive and global digital economy. Thus, promoting innovation and the development of content and applications in emerging countries will become the main objective in forthcoming years [226], [228].

The next list has a summary of the key pillars of many suggested digital strategies in order to complete the demand-side needs [226], [119], [118]

1. Develop telecommunications infrastructure and conserve the open Internet.
2. Foster the ICT area as well as its internationalization and globalization.
3. Strengthen e-government services, having access to the Public Sector Information (PSI) and data.
4. Consolidate trust to public sector (digital identities, privacy, and security).
5. Stimulate the use and acquisition of ICTs by enterprises and SMEs in special, taking into account principal areas such as (a) *healthcare*, (b) *transportation* and (c) *education*.
6. Encourage e-inclusion. Thinking about the underprivileged people and aging population.

7. Promote ICT-related skills and competencies including essential and specialized ICT skills.

8. Working on global challenges such as climate change, development cooperation, and Internet governance.

The impact of the ICTs and the Internet in the society and economy as a whole is so profound that no sector remains unaltered. Recent policies have become more horizontal, covering matters oscillating from business creation and productivity growth to public administration, employment and education, health and aging, environment and development. In such a way ICT-related policies center on empowering the positive economic and social conditions necessary for development and growth [226], [228], [281].

The Digital Agenda “Europe 2020” strategy for smart, sustainable and inclusive growth has as aim "to maximize the social and economic potential of ICT, most notably the Internet, an imperative medium of economic and societal activity”. It comprises 132 “actions”,13 grouped around seven challenging priority areas including: (i) getting the digital single market; (ii) enhancing interoperability and standards; (iii) bolstering online trust and security; (iv) popularizing fast and ultra-fast Internet access for all; (v) investing in research and innovation; (vi) promoting digital literacy, skills and inclusion; and (vii) promoting ICT-enabled benefits for EU society [226], [228].

2.6 ICT Definition

The definition of ICT has become very common and according to many specialists exists different definitions of this concept. ICTs include all kinds of technologies used for communication and for the work with information it means creating, storing, managing and communicating information [166], [288].

Wikipedia in its website defines ICT in this way:

Definition 2.2 *“Information and communications technology (ICT) is an extended term for information technology (IT) which stresses the role of unified communications and the integration of telecommunications (telephone lines and wireless signals), computers as well as necessary enterprise software, middleware, storage, and audio-visual systems, which enable users to access, store, transmit, and manipulate information. The term ICT is also used to refer to the convergence of audio-visual and telephone networks with computer networks through a single cabling or link system. There are large economic incentives (huge cost savings due to elimination of the telephone network) to merge the telephone network*

with the computer network system using a single unified system of cabling, signal distribution and management”.
(Wikipedia. "Information and communications technology", 2016)

The UNESCO on regards to ICT in education manifest that “Information and Communication Technology (ICT) can contribute to universal access to education, equity in education, the delivery of quality learning and teaching, teachers’ professional development and more efficient education management, governance and administration.” ("ICT in Education|United Nations Educational, Scientific and Cultural Organization", 2016)

2.7 Development of the ICT sector

A very important digital strategy is increasing support for the ICT sector specially promoting research and development programmes with cutting-edge network technologies, in particular, ultra-high-speed network transmission technologies, promotion of standards, venture capital investments, foreign direct investment, data processing and analysis technologies, including pattern recognition technologies; device, sensor and robotics technologies; software development and non-destructive testing, highly developed multilingual speech translation systems, export of ICT goods and services, and, promotion of “Industry 4.0”. Currently, a lot of R&D programmes are centered on cutting-edge technologies as the Internet of Things, Cloud Computing and Big Data analytics and all of them are strictly linked [120], [226], [141].

The idea is to guarantee that new ITC devices, applications, data repositories and services can interact anywhere without troubles. All countries are making decisions about the importance of the ICT sector because of the great development possibilities that it offers in this digital world [226], [229], [239].

2.8 ICT in Education

The progress of the Information and Communication Technologies (ICTs) has changed our way of life, affecting directly many areas of knowledge. In education, ICT has proven to be an exceptional support for both, teachers and students [110].

ICTs make possible the acquisition, production, storage and processing, reporting, recording and presenting information in different manners as voice, images and data contained in nature acoustic signals, optical or electromagnetic. ICTs include electronic as a technology base that supports the development of telecommunications technology, computers and audiovisual [111].

Currently, the mode of getting knowledge, the form of interchange information has been modified. ICTs are an important addition to the society life and their use guarantees to be an opportunity for apprentices to profit parity in school through several possibilities offered by technology [8].

In the world today, the promotion of the ICT, as part of schools, is stated as the highest requirement to take advantage of the technology advanced to upgrade the efficiency of instruction as a whole and ensure the acquisition of fundamental and higher ICT skills [5].

Many countries are making policies to encourage the use of ICTs and to promote Computer Science at schools, teacher formation and foment of web platform for teaching and learning. In the USA a budget of almost 4 billions of USD is dedicated for Schools and Libraries Program each year in order to ensure them access to a quality internet connectivity. There, the Federal Communication Commission FCC is investing in rural areas to obtain the mentioned objective [281], [226], [247].

The Digital Economy aims also expand and cooperate with novel and resilient educational initiatives for higher education through promoting connectivity and ICTs to spread open education environments that can be accessed from anywhere and anytime. For instance with a view to underwrite a adequate level of ICT skills in the economy, the United Kingdom's Information Economy Strategy delineates a set of actions to foster ICTs in education. One specific action include encouraging the advantages offered by Massive Open Online Courses (MOOCs) to support ICT learning [226], [166], [288], [239], [7], [167].

The world and the European Commission worried about the policies and initiatives made in order to promote the use of ICT in education, across a series of international studies had determined as strictly important the next aspects [298], [281], [166], [247].

- Schools' ICT infrastructure: The educational institutions should be equipped with desktop computers, mobile devices (laptops, notebooks, tablets, smartphones, etc.); broadband; school website, email addresses, virtual learning environment, etc.; deployment of equipment in classrooms, computer labs, libraries, etc.; maintenance). This Infrastructure is a basic condition, necessary but not sufficient [298], [281], [22], [247].

- Teachers' and students' access to ICT at school: It is necessary to experience using ICT at school (with a good % of time and frequency) having ICT-based activities during lessons, prepared by faculty and carried out by students (taking into account frequency; type of activities; digital resources used) with emphasis on the content creation [298], [281].

- Teachers' and students' digital competences: It is related to operational skills social media skills, safe and responsible ICT and Internet use; and training in order to improve the digital literacy [298], [281].
- School strategies and leadership: Each institution have to implement policies about ICT use in teaching and learning and in subjects by the whole school community; facilitating time for teachers to collaborate and network; incentives to reward ICT use; creativity and innovation policy, etc. [298], [281].
- Opinions and attitudes of school principals, teachers and students on regards ICT relevance, impact, achievement and motivation on learning [298], [281].

In the age of technology, the ICT and the Internet are linked together in this educational revolution. Great knowledge of ICT is a base for the modern Internet systems.

Chapter 3

Internet History and Evolution

"In the history of science it is fairly common that new technologies are ultimately what make new areas of basic science develop. And thus, for example, telescope technology was what led to modern astronomy, and microscope technology to modern biology. And now, in much the same way, it is computer technology that has led to the new kind of science..."

Stephen Wolfram

3.1 Introduction to the Internet

According to different researchers [128], information is the fourth scientific revolution. The first was when the premier astronomer, Nicolaus Copernicus (1473–1543) formulated a scientifically-based heliocentric cosmology that removed the Earth and hence humanity from the center of the cosmos. The second was when Charles Darwin (1809–1882) determined that all species of life have develop gradually over time from common predecessors through natural selection, displacing in this way humanity from the center of the biologic realm. When Sigmund Freud (1856–1939) confirmed that mind is also unconscious, and can be affected by the mechanism of repression, accordingly, people are not completely transparent to themselves, in other words, people are not Cartesian minds, this is considered the third revolution. Finally, the fourth is the revolution of the information, the "Big Data" and its analysis will give the power to rediscovering the humanity paper in the world and outside of it. The information age could be an opportunity to foresee complications, recognize possibilities and solve problems. [128], [92].

Currently, the internet has transformed the computer science and communications age as never has been seen before. Many inventions such as the telegraph, the telephone, the radio, and the computer set up the scenario for this phenomenal integration of potentialities.

The Internet is a logical system for information diffusion and it has at the same time a planet-wide diffusion capacity becoming a channel for cooperation and interaction among people and their digital devices freely wherever they are and whenever they want in real time, the geographic location and distances are not anymore a limitation. The invention of the Internet is considered one of the most successful results of the serious investing in research and teamwork among academia, government, and industry [191], [128], [92], [154].

The multiple and difficult to understand metamorphosis of today on regard to technology have the origin in the form in which the Internet was created. It was in summary thanks to the investments of the Advanced Research Projects Agency (ARPA) of the U.S.A. Department of Defense . [92].

The main interest of researchers was to get links of communication between remote places without dependent on electrical service. At the beginning, Internet was developed and used by specific research teams, located in universities and telecommunication enterprises that were seriously promoting investment in booming research. Thus, this ideal expanded during the 60s and 70s, where a computers' network started to using "packet switching" to transmit data between each other [92].

Nowadays the Internet attends and responds to the biggest and most varied collectivity of users connected to the world network. A brief and chronology historical summary is provided in this chapter to set the scenario for understanding the challenges and the Internet's development.

3.2 Definition

The Internet is defined as:

Definition 3.1 *"A global computer network providing a variety of information and communication facilities, consisting of interconnected networks using standardized communication protocols".*
– From the Oxford dictionary

Definition 3.2 *"The Internet is the global system of interconnected computer networks that use the Internet protocol suite TCP/IP (Transfer Control Protocol / Internet protocol) to link billions of devices worldwide. It is a network of networks that consists of millions of private, public, academic, business, and government networks of local to global scope, linked by a broad array of electronic, wireless, and optical networking technologies. The Internet carries an extensive range of information resources and services, such as the inter-linked hypertext documents and applications of the World Wide Web (WWW), electronic mail, telephony, and peer-to-peer networks for file sharing".*
– From Wikipedia

3.3 Origins of the Internet

The origin of the Internet began in the USA in the 1960s decade. In the "Cold War" lapse, the United States and the Soviet Union with their controversy and lust for power divided the world, viewing each other with great prudence and attention. This framework started many years before, but, the most important event that alerted to the United States was the launch of the first space satellite Sputnik by the Soviet Union in 1957, October 4th. This success required an American reaction, it was a principle of honor at that time. In 1958, the United States Department of Defense i.e. the American Army answered by founding the ARPA (Advanced Research Projects Agency), now called DARPA dedicated to foster research and compete with the Soviet Union, and also try to have warranties against a possible attack with missiles by the space. The USA army was especially worried on regards to the consequences that this nuclear attack, could cause to their communications bases [92], [264], [158], [253].

According to Stewart, in the first book published on the web, 2000, the conceptual foundation for creation of the Internet was given by three people and a research conference, each of which transformed the trend we thought about technology by precisely predicting its future:

- Vannevar Bush, wrote the first visionary description of the potential uses for information technology with his description of the "memex" automated library system on July 1945. *"A memex is a device in which an individual stores all his books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory" Vannevar Bush; As We May Think; Atlantic Monthly; July 1945* [264].

- Norbert Wiener, invented the field of Cybernetics, encouraging future scientists to approach on the use of technology to expand human competences. For Wiener, the term cybernetics concerned to the combination of man and electronics, which he first published in 1948 in the book Cybernetics [264].

- The Dartmouth Artificial Intelligence conference at Dartmouth College in Hanover, New Hampshire (1956), settled the idea that technology was improving at an exponential proportion, and predicted the importance of the consequences [207].
- Marshall McLuhan built the conception of a "global village" interconnected according to his metaphor by an electronic system and it could be integrated into the community culture [264].

3.3.1 First Steps on the Internet Development

In ARPA, one of the important offices was the Information Processing Techniques Office (IPTO). It funded research in computer science designed to mobilize American universities and research laboratories to build up a strategic communication network. Was in 1962, when Licklider was nominated the director of the IPTO for the first time. His main function was to link the computers of the Department of Defense through a dispersed network. Before of that, Licklider expressed his concept of a “galactic” computer network, he conceived a universally connected group of nodes through which everyone and everywhere can enter into information and software. Afterward, Licklider and Welden Clark presented the article "On-Line Man-Computer Communication" in 1962 August, it contained an explanation of what would be the forthcoming network. Licklider tried to expand his ideas and he persuaded to Ivan Sutherland and Bob Taylor, his colleagues, and replacements at DARPA, and also to Lawrence G. Roberts, an MIT researcher on regards to the fundamental relevance of the network concept [191], [92].

Donald Davies of the NPL (British National Physical Laboratory) in 1965, started showing his thoughts on regards to packet networks and minted the word “packet”. Indeed, during that time, three researchers in different places were thinking autonomously upon similar technological issues: starting with Leonard Kleinrock, who was the initial person in working the essential principles of "packet switching". It was in 1961 when he planned his valuable concepts of this topic at the MIT laboratories, those were significant steps in the creation of the Internet. The second was Baran at RAND (is an institution dedicated to investigating and give solutions to public issues), he stated the notion of "standard-size addressed message blocks and adaptive alternate routing procedures" with broadcast control. And third, Davies reflected as well in the same way that to accomplish a fast communication among computers a "message-switching communication service" was required, in which the longest messages could be divided into pieces and delivered apart in order to diminish the danger of possible agglomeration [92].

This initiative led the creation of the ARPANET (ARPA Network) seven years later in August 1969; it was released by BBN (Bolt Beranek and Newman) corporation, after that, the NSFNET (National Science Foundation Network) also was created. It constituted an organization charged of managing projects and research patronized by the NSF (National Science Foundation) [264], [158].

It was ARPA that sponsored some of the initial research about networking, completed by Lawrence Roberts. Later, ARPANET nominated Lawrence Roberts as its Program Manager [264].

At that time, ARPA had open permission to do and use the mediums that they considered proper to develop the technological area. Consequently, ARPA 18 months after of its foundation had built and sent the first satellite of the USA. Since its origin ARPA essentially had sponsored and established numerous research laboratories located at the main USA universities, this facilitated that ARPA had got by 1968 a strong relationship with several universities as Carnegie-Mellon University, Harvard University, MIT, Stanford university, University of California Berkeley (UCB), University of California at Los Angeles (UCLA), the University of California at Santa Barbara (UCSB), University of Illinois, and the University of Utah, besides power and important industry laboratories such as Bolt Beranek and Newman, Computer Corporation of America, Rand, the Stanford Research Institute (SRI), and Systems Development Corporation. The majority of this partnership laboratories were connected to ARPANET with the aim of getting a powerful process of research with many stakeholders participation.

The first communications were between Leonard Kleinrock's research center at the University of California at Los Angeles, and Douglas Engelbart's center at the Stanford Research Institute on September 1969 [264].

The continuous research started to give results, in December 1969, the first experiment was launched in order to connect four stations called nodes in an online network through 56 kbps circuits. Fig. 3.1 Illustrate the first day of ARPANET [264].

At the beginning of 1970's ARPA changed the name into DARPA, the first letter D means "Defense".

Ray Tomlinson of Bolt Beranek and Newman Company (BBN), in 1970, was working on a small team developing the operating system called TENEX with local email programs; he wrote the first email program by combining the SNDMSG (Send Messages) and CPYNET capable of copying files over the network programs [264], [172].

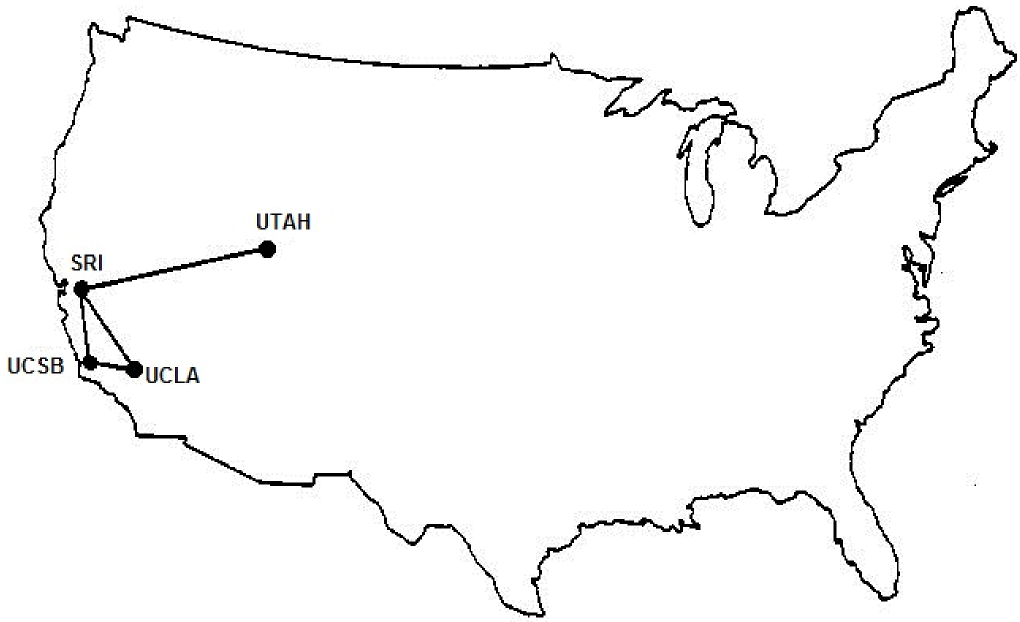


Fig. 3.1 ARPANET Architecture, December 1969.
Source: [154]

Ray Tomlinson chose the @ sign to separate local from global emails in the mailing address, so "user@host" became the standard for email addresses. Tomlinson's email program brought a complete revolution, fundamentally changing the way people communicate, including the businesses way [92], [191].

The Domain Name System (DNS) has its roots almost as early as the Internet itself. On the 1970s with the advent of email and newsgroups, the problem of locating computers on connected networks also grew [92], [191]. For managing it, a junior computer specialist, Jonathan B. Postel, who was working on the ARPA project at UCLA was committed by his own initiative to creating a way to identify the Internet's structure. Postel proposed the use of domains such as "dot-com, dot-edu, and dot-net". With Postel, In 1972 the Internet Assigned Numbers Authority (IANA) was created [253], [180].

The new technology had shown to be extremely booming and conducted to the foundation of MILNET in the U.S.A. and MINET in Europe, two parallel army networks. It expanded the possibilities and consequently many thousands of host and users interconnected their networks to the ARPANET. In this way was created the original "ARPA Internet". Fig. 3.2 illustrate its growing number of connectors in 1976.

The first networking protocol used was the Network Control Protocol (NCP). In 1983, it was replaced with the TCP/IP protocol (Transfer Control Protocol/Internet Protocol) invented

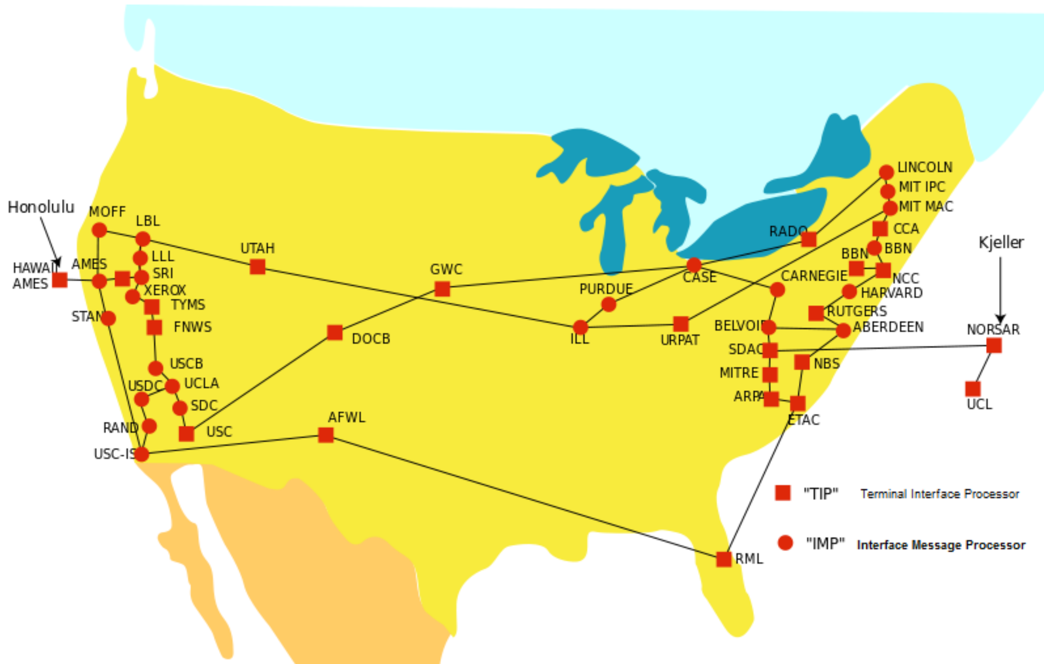


Fig. 3.2 ARPANET Architecture, July 1976.
Source: (ARPANET- Wikipedia), Halabi, 2000 [154] and Leiner, 2009 [191]

by Robert Kahn, Vinton Cerf, and others, which quickly became the most widely used network protocol in the world [264], [253], [158], [191], [154], [180].

The conglomeration of different networks was the beginning of the well known Internet. Nonetheless, ARPANET had an Acceptable Usage Policy (AUP) that prohibited the use of the Internet for commercial purposes. In 1990, the ARPANET was decommissioned and transferred to the NSFNET. The NSFNET was soon connected to the Computer Science Network (CSNET), to link Universities around the USA, and then to the EUnet, to connect research centers in Europe. See Fig. 3.3

As example of the growing process Fig. 3.4 shows the NSFNET between 1988-1990.

Quickly, the use of the Internet exploded after 1990, causing the USA Government to transfer the Internet management to independent organizations starting in 1995 [264], [154]. See Fig. 3.5.

Later, Tim Berners-Lee, a graduate of Oxford University created the World Wide Web in 1989 helped by Robert Cailliau at the European Particle Physics Laboratory CERN (Conseil Européen pour la Recherche Nucleaire). He founded and Directs the World Wide Consortium (W3C) (www.w3.org) the forum for the technical development of the Web. Whose mission is that the WWW serves Humanity. In 1990, Tim Berners-Lee also developed the first web client and server and at the same time that the web technology was expanding, his detailed statements about URIs, HTTP and HTML were debugged [264], [92], [191], [253], [180].

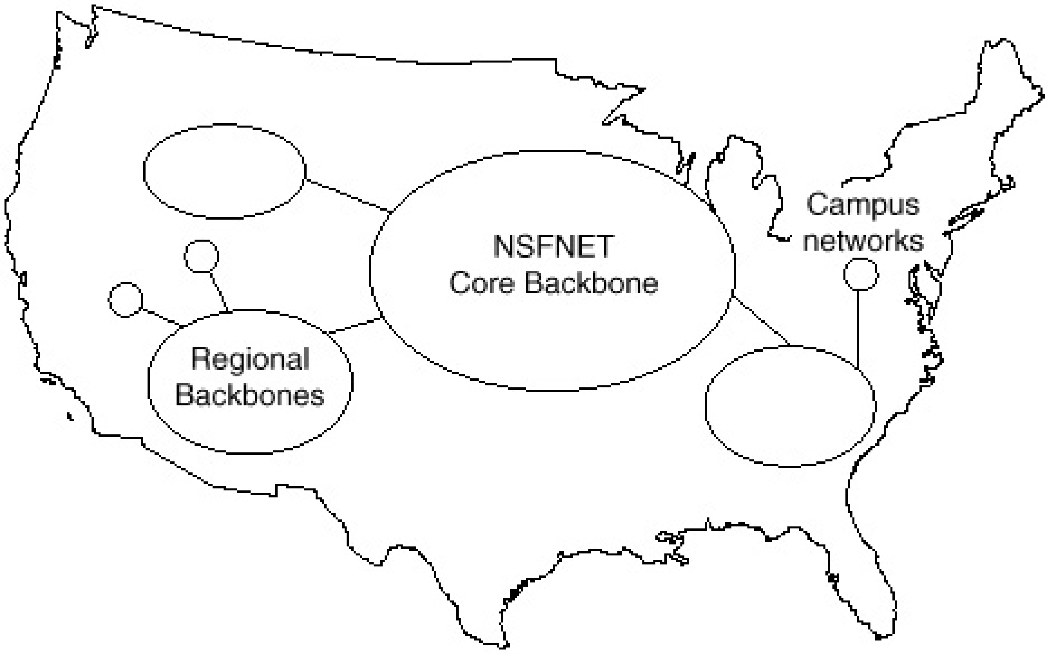


Fig. 3.3 National Science Foundation Network (NSFNET)
Source: [154]

Fig. 3.4 T1 National Science Foundation Network (NSFNET) 1988-1990
Source: [154]

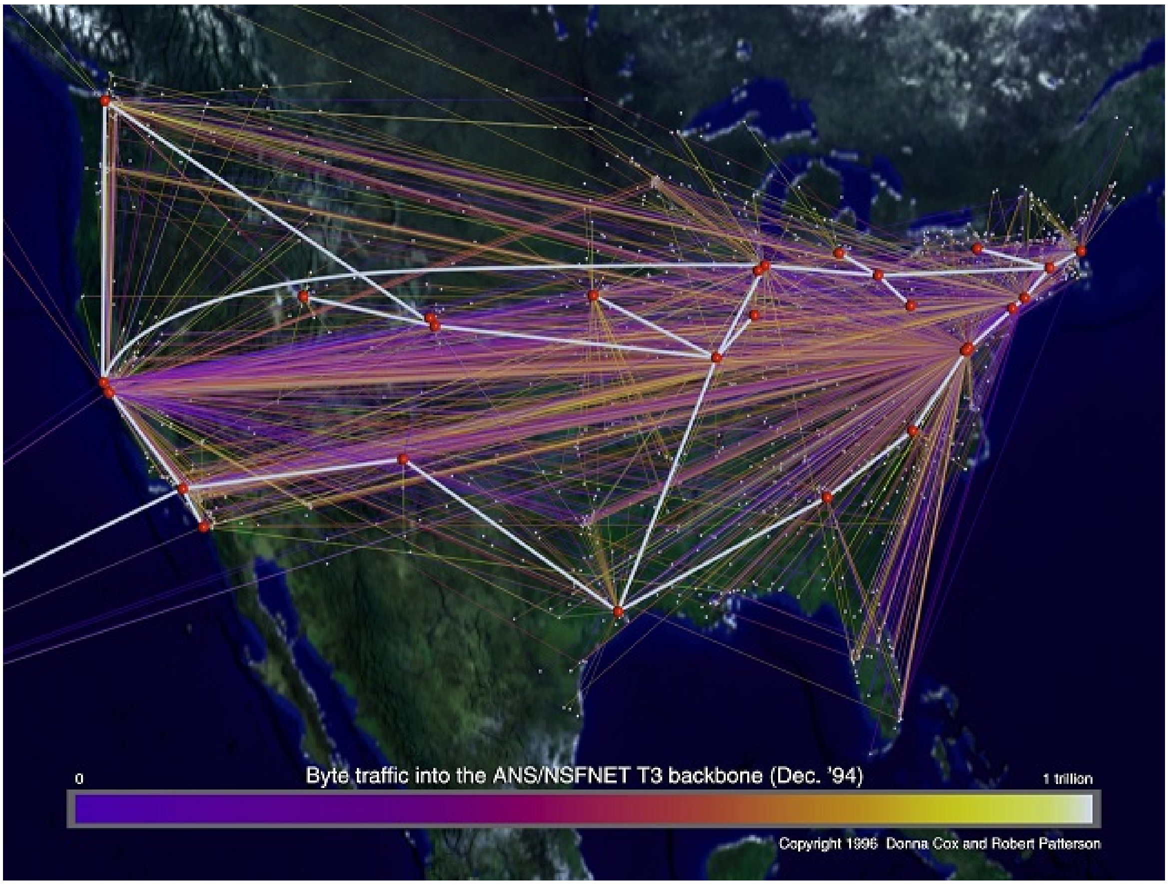


Fig. 3.5 National Science Foundation Network (NSFNET) December 1994. A view from 45 degrees with US geometry. University of Illinois This image represents byte traffic into the ANS/NSFNET T3 backbone (45 Mbits/s) from its client networks for the month of December '94. The virtual connections, colored by traffic level, visualize traffic statistics collected by Merit Network Incorporated. December marks the last heavy usage month prior to the NSFNET's decommissioning in April of '95. Backbone service has now transitioned to a number of commercial carriers.
Source:
$http://virdir.ncsa.illinois.edu/virdir/raw-material/networking/nsfnet/NSFNET_1.htm$

3.3.2 The Astronomical Extension

The easy accessibility to Internet, the multi- applications and its decentralized nature were fundamental for its rapid development and growth. In the 1990s an astronomical expansion of the net was observed. Personal computers and business and companies with different operating systems joined the universal network. In few time, the Internet became a global phenomenon, more countries and people joined it, expanded the skyline of the platform with many new and creative novelties [191], [180].

In few years the connection between IP addresses was something like a neuronal network as shows Fig. 3.6

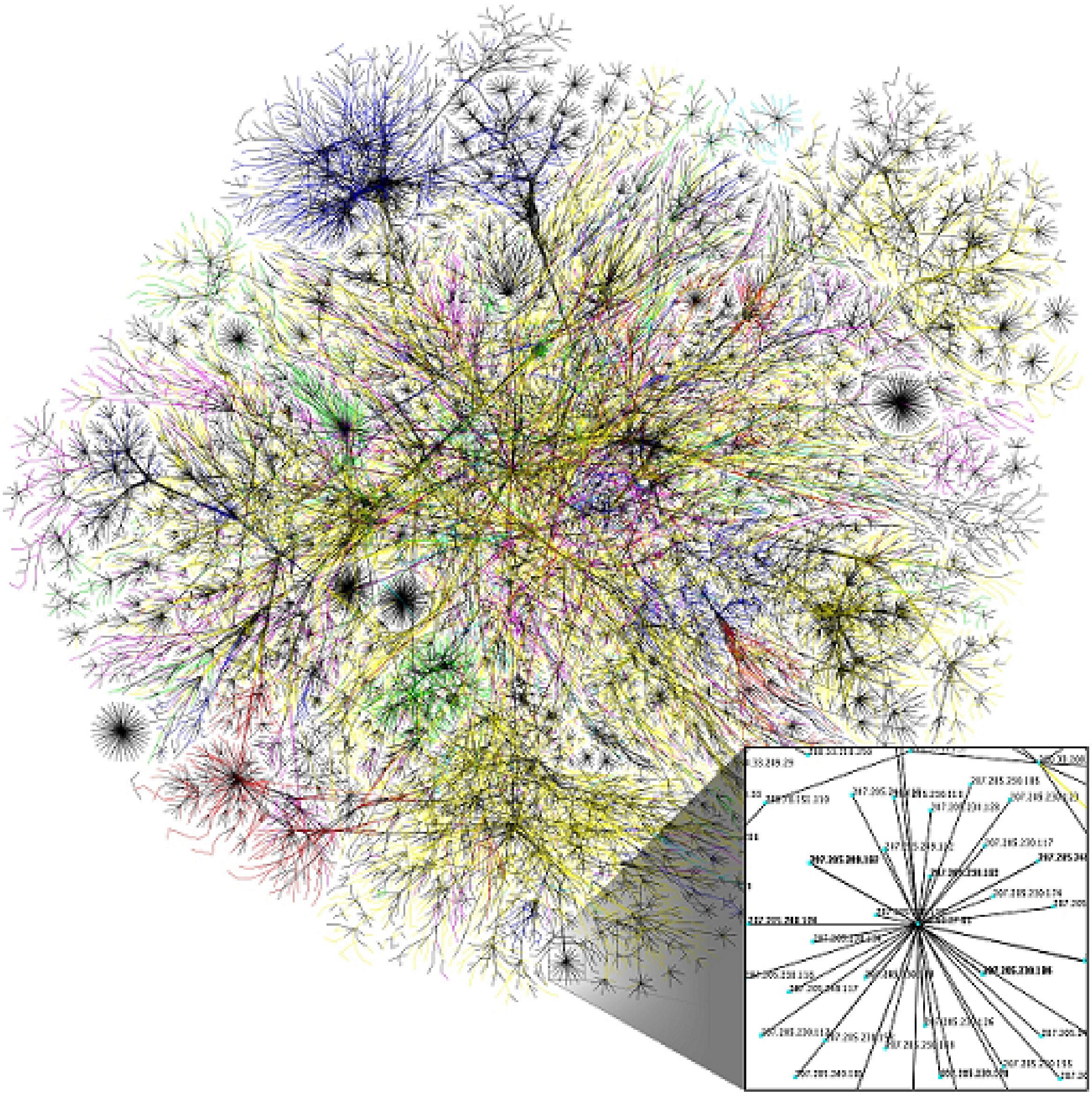


Fig. 3.6 Partial map of the Internet based on the January 15, 2005 data found on opte.org. Each line is drawn between two nodes, representing two IP addresses. The length of the lines are indicative of the delay between those two nodes. This graph represents less than 30 % of the Class C networks reachable by the data collection program in early 2005. Lines are color-coded according to their corresponding RFC 1918 allocation as follows: net, ca, us com, org mil, gov, edu jp, cn, tw, au, de uk, it, pl, fr br, kr, nl unknown
Source: Wikipedia

Furthermore, the Internet Society was created and Croatia (HR), Hong Kong (HK), Hungary (HU), Poland (PL), Portugal (PT), Singapore (SG), South Africa (ZA), Taiwan

(TW) and Tunisia (TN) joined the NSFnet network whose backbone was upgraded to DS-3 (44.736 Mbps) as the traffic passed to 1 trillion bytes and 10 billion packets per month [264], [92], [191], [253], [180].

This astronomical growth of the Internet currently and until 2020 can be summarized with the next data information updated from Cisco Systems, the American corporation technology company (http://www.cisco.com/). See Fig. 3.7.
Cisco reported that the annual global IP traffic will overcome the zettabyte (ZB; 1000 exabytes [EB]) horizon in 2016, and will extend to 2.3 ZB by 2020. Global IP traffic will range 1.1 ZB per year or 88.7 EB (one billion gigabytes [GB]) per month in 2016. By 2020, global IP traffic will scope 2.3 ZB per year, or 194 EB per month [88].

Corresponding to this prognostic, global IP traffic in 2015 remained at 72.5 EB per month and will nearly triple by 2020 to extend to 194.4 EB per month. Users IP traffic will range 162.2 EB per month and business IP traffic will overcome 32.2 EB per month by 2020. The main results took from Cisco said:

- Globally, Internet traffic will grow 3.0-fold from 2015 to 2020, a compound annual growth rate of 25%.
- Busy-hour Internet traffic will grow 4.6-fold from 2015 to 2020, a compound annual growth rate of 36%.
- Internet traffic will extend to 161.3 Exabytes per month in 2020, up from 53.2 Exabytes per month in 2015.
- Global Internet traffic will be 5.3 Exabytes per day in 2020, up from 1.7 Exabytes per day in 2015.
- Internet traffic in 2020 will be tantamount to 484 billion DVDs per year, 40 billion DVDs per month, or 55 million DVDs per hour.
- For 2020, every 2 minutes the tantamount in gigabytes to the movies capacity made until the moment will traverse the Internet.
- Per capita in 2020 the Internet traffic will overcome the 21 Gigabytes, this statistic over pass in 7 Gigabytes in relation with the results per capita in 2015. In 2020 the Internet traffic will be similar to 95x the volume of the Global Internet traffic produced in 2005.
- The Internet traffic average will rise 3.0-fold by 2020 and will reach 491 Tbps.

- The number of DDoS (Distributed Denial of Service) attacks will grow 2.6-fold from 2015 to 2020, a compound annual growth rate of 21%. This number will be 17.4 million per year in 2020, up from 6.6 million per year in 2015.

Taking into account the Compound Annual Growth Rates (CAGR) whose formula is 3.1

$$CAGR = \left(\frac{EndingValue}{BeginningValue}\right)^{\frac{1}{\#ofyears}} - 1 \tag{3.1}$$

So that, Fig. 3.7 shows the globally forecast highlights results according Cisco:

- There will be 26.3 - 50 billion networked devices in 2020, up from 16.3 billion in 2015;
- 3.4 networked devices per capita in 2020, up from 2.2 per capita in 2015.
- 44% of all networked devices will be mobile-connected in 2020.
- M2M modules will account for 46% (12.2 billion) of all networked devices in 2020, compared to 30% (4.9 billion) in 2015, (20% CAGR).
- PCs will account for 5% (1.4 billion) of all networked devices in 2020, compared to 9% (1.5 billion) in 2015, (-1.9% CAGR).
- Tablets will account for 3% (838.4 million) of all networked devices in 2020, compared to 3% (537.2 million) in 2015, (9.3% CAGR).
- Smartphones will account for 21% (5.6 billion) of all networked devices in 2020, compared to 19% (3.0 billion) in 2015, (13.1% CAGR).
- Connected TVs will account for 12% (3.1 billion) of all networked devices in 2020, compared to 11% (1.8 billion) in 2015, (11.6% CAGR).
- Non-Smartphones will account for 9.2% (2.4 billion) of all networked devices in 2020, compared to 24% (3.9 billion) in 2015, (-9.4% CAGR).
- Other Portables will account for 3% (785.0 million) of all networked devices in 2020, compared to 3% (560.8 million) in 2015, (7% CAGR).
- 4K TVs will account for 40% (543.7 million) of all flat panel TVs in 2020, compared to 7.7% (37.7 million) in 2015, (70.5% CAGR).

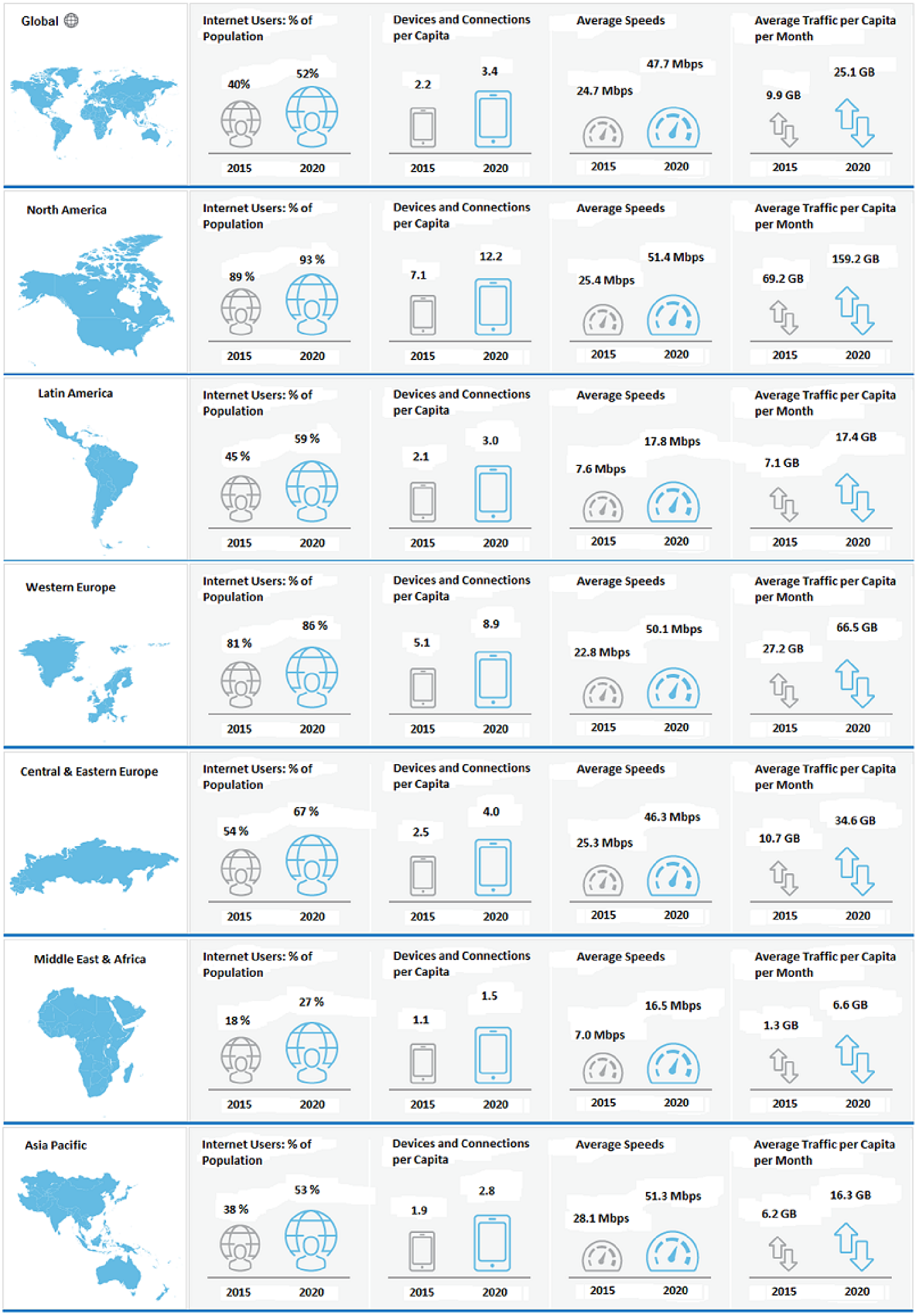


Fig. 3.7 Cisco Visual Networking Index (VNI) Complete Forecast Highlights. Source: [88]

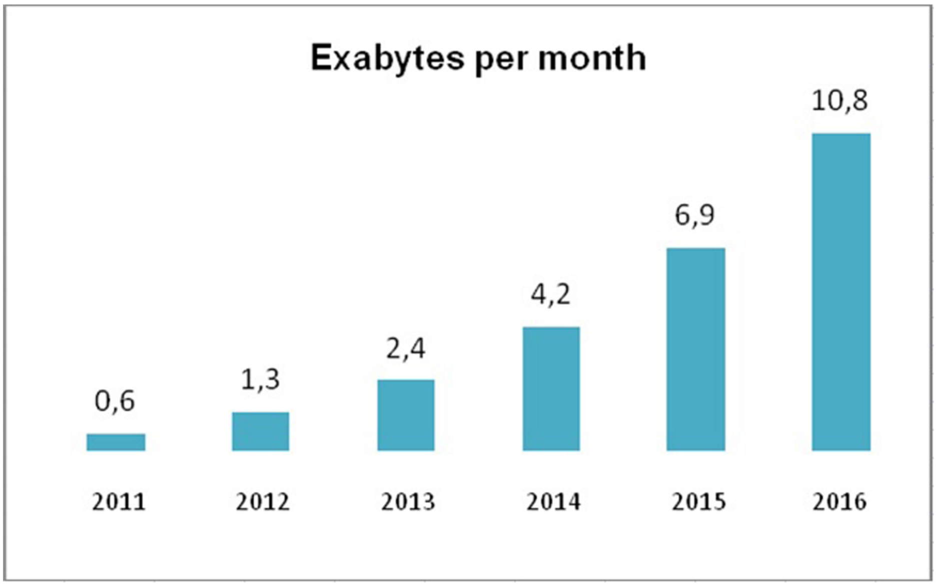


Fig. 3.8
Mobil Data forecast, adapted from Cisco
10.8 Exabytes per Month of Mobile Data Traffic by 2016
Source:Cisco

- Global IP traffic from non-PC devices was 47% of total IP traffic in 2015, and will be 71% of total IP traffic in 2020.
- PCs accounted for 53% of IP traffic in 2015, and will be 29% of IP traffic in 2020.
- TVs accounted for 30% of IP traffic in 2015, and will be 25% of IP traffic in 2020.
- Smartphones accounted for 8% of IP traffic in 2015, and will be 30% of IP traffic in 2020.
- Tablets accounted for 7% of IP traffic in 2015, and will be 13% of IP traffic in 2020.
- M2M modules accounted for 1.4% of IP traffic in 2015, and will be 3.2% of IP traffic in 2020.
- PCs accounted for 63% of consumer Internet traffic in 2015, and will be 29% of consumer Internet traffic in 2020.
- TVs accounted for 11% of total Internet traffic in 2015, and will be 12% of total Internet traffic in 2020.

In addition at this time, the traffic on Internet is measured in Exabytes per month, and the Mobil Data according to Cisco has this behavior. See Fig. 3.8.

3.4 The Next Internet Evolution

Nowadays, the Internet infrastructure is getting stronger than before, it will not disappear, besides it will retain its central role as global backbone for worldwide information sharing and distribution, interconnecting physical objects with computing/communication facilities across a large range of services and technologies [18].

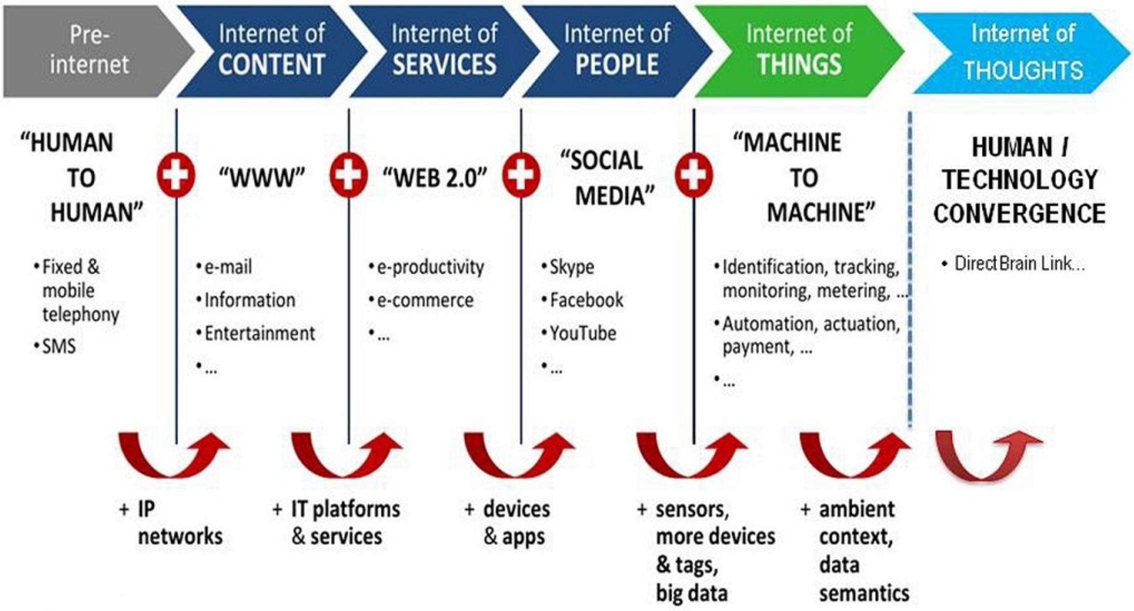


Fig. 3.9 The Next Internet Evolution
Source:Image Adapted from @Alcatel-Lucent

The next evolution of the Internet is represented by the Internet of Things (IoT), taking a colossal jump in its capability to assemble, analyze, and distribute data that everyone can transform into intelligent information, knowledge, and finally wisdom. Whit this background, IoT becomes enormously substantial [121], [296].

See Fig. 3.9. It shows how Standardization enables the Next Internet Evolution and adding the futuristic prediction of the Internet of Thoughts

IoT sometimes called also as the "Internet of Objects", is changing the complete technological panorama. Considering the impact that the Internet has generated on all sectors of society development. Definitely, it is possible to say, that the Internet has become in a transcendental and successful invention of the whole world history [121].

Currently, IoT research, projects, and products are in process with the commitment to reduce and cancel the breach among poor and rich people, achieving a better allocation of the resources in the world thinking in the vulnerable groups and helping individuals understand the planet, only then society can be more conscious [121], [296].

Now is the moment in which businesses, governments, standards bodies, and academia should work together to face the challenges, IoT will keep progress. See Fig. 3.10

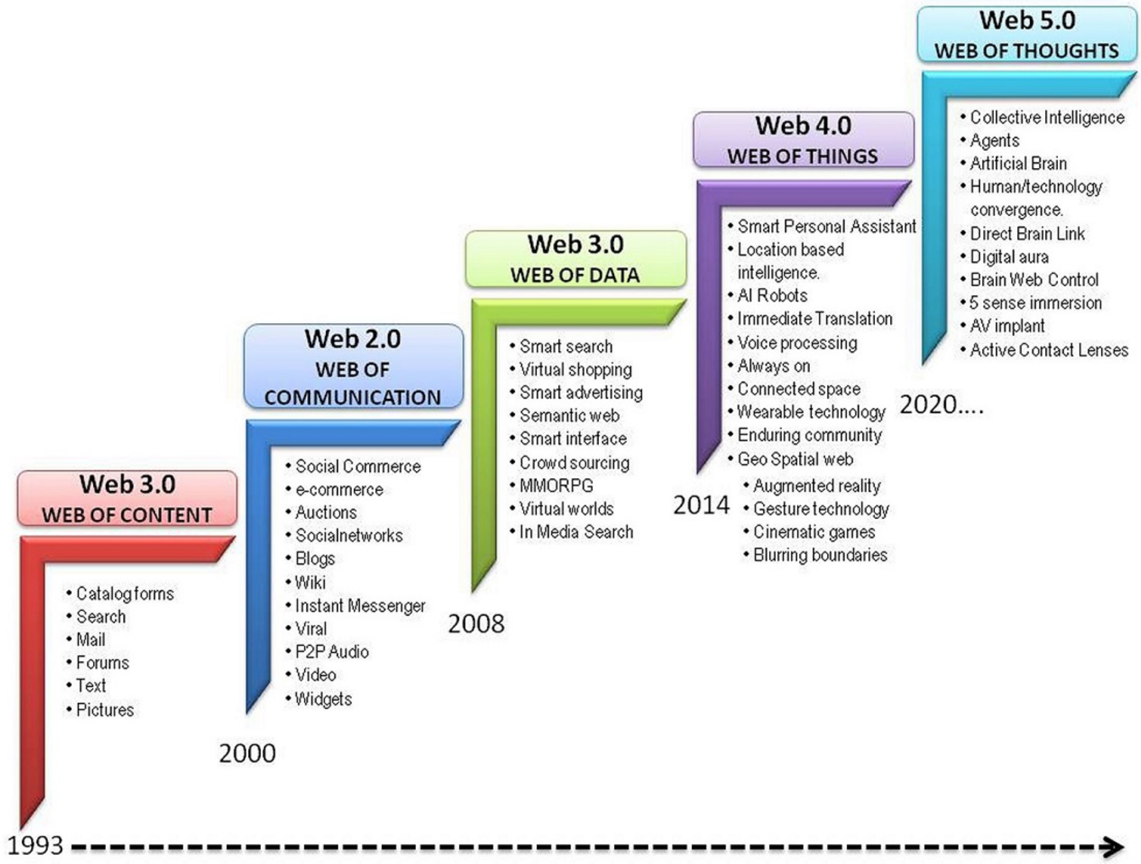


Fig. 3.10 The Web Expansion.
Source: Image adapted from the ideas of the futuristic Neil Müller of TrendONE

3.5 Massive Open Online Courses (MOOCs)

The Internet evolution changed the life and education, 2012 became on "the year of the MOOC" according to The New York Times. Most of the top universities turned on to this novel approach and started given online education service well know as e-learning [305].

On the Wikipedia website, the following definition of Massive Open Online Course is provided:

Definition 3.3 *“A Massive Open Online Course (MOOC) is an online course aimed at unlimited participation and open access via the web. In addition to traditional course materials such as filmed lectures, readings, and problem sets, many MOOCs provide interactive user* *forums to support community interactions among students, professors, and teaching assistants (TAs). MOOCs are a recent and widely researched development in distance education which were first introduced in 2008 and emerged as a popular mode of learning in 2012". Wikipedia, 2016. [305]*

The definition express a general concept of MOOCs. It is considered first of all as an educational model that is massive, in theory with no limit to registration; online, open, permitting the participation of everybody often at free cost, with structured courses founded on learning objectives of a specific study area or subject with academic exercises and activities on the web. MOOCs have promoted an re-evaluation of higher education, faculty and educational institutions in order to get accreditation around the world [115], [240].

MOOcs usually works in a similar way to formal and traditional online higher education courses. Each MOOC has a syllabus and course content. The activities and assignments generally are composed of readings, lectures; online discussions, chats, forums, quizzes, etc. These can change by face-to-face meetings between participants if they live close to each other [115].

In most of the cases, MOOCs are conducted by organizations that incorporate education in their mission, they can be either nonprofit or for-profit. Are the organizations to decide the level or the course to offer. MOOCs could be offer by an institution or its own. Some MOOCs include a fee or tuition for students enrollment or certificate for completion [115].

3.5.1 A brief history of MOOCs

Distance learning started before of the digital age in the form of correspondence courses in the 1890s-1920s, after that, radio and television offered courses and some form of e-learning. Usually, only five percent of the students would complete a course. The 21st-century started and saw big changes in e-learning and distance education, with the beginning of MOOCs, showing the rising of online presence and open learning opportunities [305].

MOOCs could be described as the natural evolution of Open Course Ware, first created by the MIT in 2001. Thus, the MIT at the beginning with MITx and then with edX also started the development of MOOCs [101].

It is no really clear when and where was offered the first MOOC. First, David Wiley was who taught an online graduate course in open education by anyone around the world at Utah State University, in 2007. The same year in Ireland, Advance Learning Interactive Systems Online (ALISON) was founded. But, it wasn't until 2008 that the word MOOC was minted by Dave Cormier, from Prince Edward Island's University in Canada. Cormier used the term to describe (CCK08 Connectivism and Connective Knowledge course) an open course created by George Siemens and Steven Downes and offered to twenty five scholars at the Manitoba's University [305], [277], [94], [93].

The first MOOCs were deeply collaborative and called cMOOCs, their philosophy principles emphasize learning as a process of sharing and building knowledge within a community of people, connecting specialized sets of information embedded in social and technological networks and platforms [305], [277], [94], [93].

This philosophy has evolved to a commercial meaning and this is the second type of MOOCs namely xMOOCs. These xMOOCs are founded on more traditional model of education, based on lectures recorded in videos using innovative technology, and usually are financed [305], [277], [94], [93].

In 2011, Stanford University offered a course online and for free on artificial intelligence having as professors Sebastian Thrun and Peter Norvig. One hundred and sixty thousands students registered and only twenty thousand students completed the course and got a "statement of accomplishment". After, another Stanford professor, Andrew Ng, taught an online course on machine learning having one hundred thousand students [94], [93].

In 2012, Sebastian Thrun and Andrew Ng founded the xMOOC platforms Udacity and Coursera, respectively. The third xMOOC platform, edX was founded in 2012 too by a partnership between MIT and Harvard [94], [93].

Currently MOOCs are offered by universities in association with partners such as Coursera, Udacity, and edX [305], [277], [94], [93].

3.5.2 General framework of a MOOC

The most popular structure of a MOOC has a duration from 6 to 12 weeks.The main characteristic is that a MOOC is accessible 24/7 (twenty-four hours a day, seven days a week). Most of the content is delivered asynchronously it means that students can access it anytime and anywhere on their own schedule. There are also synchronous activities, which demand students to join in at the specific timetable.

The assessment process in a MOOC is usually by multiple-choice questions using technology tools of the platform.

Assignments are an important component. Participants have to upload them into the MOOC platform, so these can be graded and assessed in different ways:

- Automatically when it is possible
- Peer-to-peer: students grade themselves

- Using other components as a forum, where participants make questions that other peers could answer

Generally, there are no prerequisites for taking a MOOC, just having an internet connection and a computer. Normally, the academic background of participants isn't significant.

The majority of the MOOCs reported by researchers are resembled xMOOCs which are similar to the structure of traditional courses run by colleges and universities with pre-recorded video lectures by professors, examinations and/or individual final project (upload online) [163].

3.6 Learning Management Systems (LMS)

A MOOC as it was explained is a course that usually is hosted by a platform called a Learning Management System (LMS). Some of the most known MOOC platforms involve both a MOOC and an LMS as Coursera and edX.

Definition 3.4 *"LMS is the framework that handles all aspects of the learning process. An LMS is the infrastructure that delivers and manages instructional content, identifies and assesses individual and organizational learning or training goals, tracks the progress towards meeting those goals, collects and presents data for supervising the learning process of an organization as a whole. An LMS delivers content but also handles course registration and administration, skills gap analysis, tracking, and reporting". Watson, 2007 [299]*

According to the American Society for Training & Development an LMS has include the next requirements [299]:

- enable integration with the human resources system
- incorporate tools which manage user registrations
- establish curricula and certification ways, assign tutors and tutorials
- administer budgets,
- prepare schedules for learners, tutors, classrooms and courses.
- provide access to content for instructors and learners develop content, maintaining and storing, integrate content from other sources.
- assess learners

- include standards well known, as SCORM (Sharable Content Object Reference Model) and AICC (Aviation Industry CBT (Computer-Based Training) Committee) which permit importing content and courseware.
- provide security such as passwords and encryption

These are in a general view the main characteristics of an LMS, particular items depend on of the organization [299], [255].

In concordance with PC magazine , the best LMS for 2016 are: Absorb LMS, Grovo LMS, Moodle LMS, Schoology LMS, Edmodo LMS, Instructure Canvas LMS, Axis LMS, SmarterU LMS, Halogen TalentSpace LMS [198].

LMS sellers usually charge per month, for reducing bills, customers can pay for a year up front. Moodle is very popular because is free, open source, and un-hosted; in the other hand there are the all-inclusive with different costs [198].

Chapter 4

The Internet of Things (IoT)

> *"Since we entered into the age of information and telecommunications in the 70's we had not seen anything similar to the Internet of Things in terms of its potential impact on process change and business ecosystem generation. The IoT is more than a new generation for the Internet, it is the next technological revolution, horizontal and global, in which we will finally see the digital and physical world blended"*
>
> Alicia Asín
> Co-founder of Libelium Company

4.1 Introduction to the Internet of Things

With the atomic growth of ICT devices, wireless technologies have become a primary tool for everyday life around the world. The already wave of connected devices, appliances, vehicles, sensors, meters and countless other ***"things"*** represents the new generation of a hyper-connected world, the Internet of Things (IoT) [259].

The IoT goal is to extend the benefits of the normal Internet into a constant connectivity, remote control ability, data sharing and so on in the physical world. Everything would be tied to local and global networks, through embedded sensors that are always on [259].

In the age of communication, the current phase of the Internet is on its way: a world of networked smart devices connected each other and known as the Internet of Things. The IoT links smart objects to the Internet. IoT could enable a data exchange never seen before, and of course bring users information in secure form [121]. Cisco estimates by 2020, the IoT will consist of 50 billion devices connected to the Internet. In a future scenario the use of the IoT Systems will enhance productivity, create new business models, and generate new revenue streams, the world has experimented a very speed technology revolution [121], [88].

The new technological paradigm of the IoT, so-called the Industrial Internet, is understood as a worldwide network of digital devices able to communicating between them without human intervention [188].

The IoT links smart objects to the Internet. It can enable an exchange of data never available before, and bring users information in a more secure way. In fact, IoT will also allow to enhance productivity, create new business models, and generate new revenue streams [147].

The cutting edge technology of computing is outside the sphere of the conventional idea. In the IoT paradigm, most of the objects that wrap us will be on the network in any way [151]

Technology related to sensor networks and Radio Frequency IDentification (RFID) will increase to satisfy the new growing demand for privacy and protection of the embedded systems in the environment surrounding us. As a result, it produces a large quantity of data, "Big Data" that needs to be "stored, processed and presented" in an interpretable and easily manageable mode [147], [121], [313].

The speed propagation of the IoT will drive the extensive adoption of new IoT devices, platforms and related technology according to the application and use. Nevertheless, it is necessary to be aware, in most instances, IoT solutions will be obtained by combining new IoT technologies with existing applications and data. This will create unique challenges in IoT projects with existing investments on regards to Big Data analytics, information management, cyber security, etc. [121].

The Gardner prevision shows many optimistic results with the IoT use. It said this could create a great opportunity for Software Monetization. The trends on regards IoT brings many research questions and investments. Currently, the Internet can be thought of as a combination of an "Internet of People," an "Internet of Information," an "Internet of Things" and an "Internet of Places". The great combination of all of these is tremendous. The IoT could transform every producer or maker into a software provider, which will have an erudite impact on application tactics, architecture, development and integration approaches. (http://www.gartner.com/).

See Fig. 4.1. It shows the IoT on the top, it means is the emerging technology to be developed in the next 5-10 years

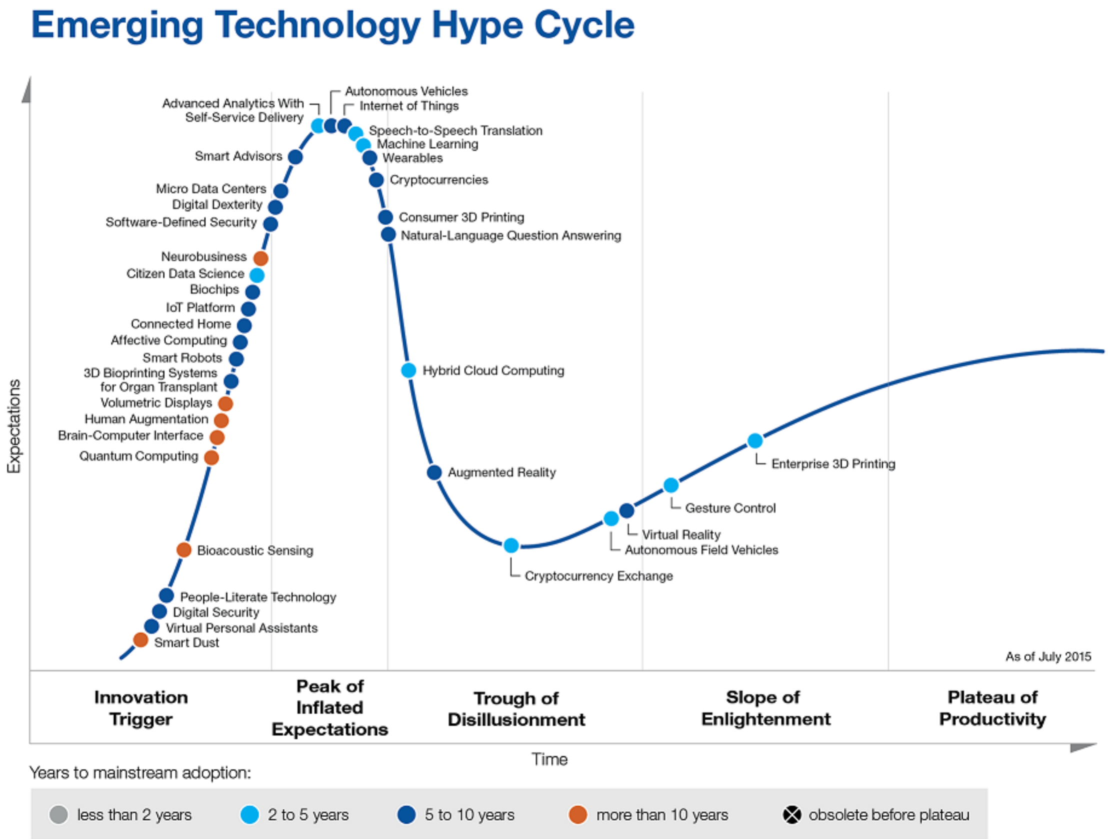


Fig. 4.1 Gartner Hype Cycle of the Emerging Technology 2015
Source:Image Adapted from @Alcatel-Lucent

4.2 IoT Definition and Vision

It is expected that during this almost ended and next decade, the Internet will exist as a perfect landscape of classic networks and networked objects. Information and services will be all around everyone, always available, preparing the path for novel applications or requests, also allowing new forms of performance, interaction, entertainment, and living [18].

The IoT is raising rapidly, challenging and demanding tasks to face the future Internet, market, policy, and society models. The IoT depicts a future computing scenario, where everyday things (physical objects) are linked to the Internet and are capable of detecting other digital apparatus. The thing in IoT can be consider an individual with an inserted cardiac monitor, a pet with a chip or any animal with a transponder, a vehicle with sensors incorporated to alert the owner about different matters on regards the object function, or any normal or manufactured thing, that can be allocated an IP address in order to send, pass and interchange valuable information online [259], [254].

In order to better understand the definition, it is necessary to express first of all that the terminology “Internet of Things” was minted by the British businessman Kevin Ashton in 1999, when he described connectivity among physical objects via ubiquitous sensors in its original form [12]. After formally the IoT got more acceptation and according to it: from anytime, anyplace will have connectivity for anyone, and now also connectivity for anything [237].

Definition 4.1 *“The internet of things (IoT) is the network of physical devices, vehicles, buildings and other items—embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data. In 2013 the Global Standards Initiative on Internet of Things (IoT-GSI) defined the IoT as "the infrastructure of the information society." The IoT allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic”.*
- From Wikipedia

Definition 4.2 *“A world where physical objects are seamlessly integrated into the information network, and where the physical objects can become active participants in business processes. Services are available to interact with these ’smart objects’ over the Internet, query their state and any information associated with them, taking into account security and privacy issues"”.*
- From: Internet of Things: Legal Perspectives. By Rolf H. Weber, Romana Weber.
(http://www.postscapes.com/internet-of-things-definition/)

Definition 4.3 *“The expression Internet of Things is wider than a single concept or technology. It is rather a new paradigm that involves a wide set of technologies, applications, and visions. Also, complete agreement on the definition is missing as it changes with relation to the point of view. It can focus on the virtual identity of the smart objects and their capabilities to interact intelligently with other objects, humans and environments or on the seamless integration between different kinds of objects and networks toward a service-oriented architecture of the future Internet”.*
- From: The Internet of Things: 20th Tyrrhenian Workshop on Digital Communications. By Daniel Giusto, Antonio Iera, Giacomo Morabito, Luigi Atzori (Editors)
(http://www.postscapes.com/internet-of-things-definition/)

This is IoT, a term referred to a global network interconnecting smart objects and, at the same time, the set of necessary supporting technologies (RFIDs, sensor/actuators, machine-to-machine communication devices (M2M), etc.) and the collective of applications and services supporting such technologies. New opportunities for the ICT sector arise, with new services and applications able to leverage the interconnection of physical and virtual realms. From a system perspective, the IoT is an extremely dynamic network, with a large number of connected smart objects producing and overwhelming information [224], [114], [296], [211], [295].

In recent times, building the IoT has become a global trend of governments and enterprises across the planet. Government initiatives outline the basis to create smart infrastructures to improve technological infrastructures, and to construct new channels that are more progressive and accessible. Governments and industry are investing a lot of money to develop IoT computing. These examples include Japan's u-Strategy, China's National IoT Plan by the Ministry of Industry and Information Technology, the Italian National Project of Netergit, the European Research Cluster on IoT (IERC), and the UK's Future Internet Initiatives. Because IoT is increasingly become as a priority in national ICT strategies, the IoT is being planned to develop an advanced computing environment, to compile computer resources to process, store, and access to Big Data collections [147], [259].

4.3 Smart Objects (Things)

The IoT, from a theoretical standpoint, is built on three main features, on regards to the ability of "smart objects" to: (1) be identifiable (anything identifies itself), (2) to communicate (anything communicates) and (3) to interact (anything interacts) either among themselves or with end users or other entities building networks of interconnected objects with or without human intervention [212].

A smart object is considered anything that has:

1. A physical embodiment with a set of tangible features such as shape or size.
2. A basic set of communication functionalities (e.g., to send and receive messages) and
3. A single identifier, it means that it has to be associated with at least one name and one address.
4. Other required features are the basic computing capability (e.g., performing complex computations) including service discovery and network management tasks, and,
5. The ability to sense physical phenomena (e.g., temperature, light). To this classic smart objects, global network systems were included (such as RFID, wireless sensor networks WSNs and sensor/actor networks SANETs) because of the improved level of new heterogeneity devices [212], [121], [147].

The ability to interface is guaranteed by devices able to sense physical phenomena and translate them into a stream of information data and to intercept other devices. The integration, the functionalities and/ or resources obtained by the use of smart objects provides a large set of opportunities to users, manufacturers and companies [212].

In fact, IoT technologies have wide applicability in many productive sectors including environmental monitoring, health-care, inventory and product management, workplace and home support and security. Internet-of-Things has to support devices' heterogeneity, scalability (everyday objects get connected to a global information infrastructure), data sharing through wireless technologies, energy-optimized solutions, localization and tracking capabilities, self-organization capabilities (autonomy in reacting to different situations, minimizing human intervention), semantic interoperability and data management (providing adequate and standardized formats of data, models and semantic description of their content or meta-data) and embedded security and privacy-preserving mechanisms [212], [121], [147].

4.4 The Internet of Everything (IoE)

The term IoT is now largely overlapped, confused with the term Internet of Everything (IoE). IoE is considered a superset of IoT and Machine-to-Machine (M2M) communication considered a subset of IoT. In the next item an explanation of the Internet of Everything is given [302].

The concept of Internet of Everything emerged as a natural development of the IoT and is widely connected with the tactics of Cisco technologies initiatives for a new marketing domain [302]. See Fig. 4.2.

The Internet of Everything collects structured data coming from the machines thanks to IoT solutions and cross them with data and unstructured information that is provided by the people (for example, messages, tasks, signals, workflow), all within a virtual environment that facilitates collaboration between people. The IoT enables the IoE and puts it at the service of the human factor: does not replace him but enables the management of all business processes allowing the trader to pass on information, the decision and finally action [295], [121], [302], [257].

Cisco expresses, the IoE assembles people (human beings), process (administrates the form in what people, data, and things work together), data (valuable information), and things (objects and digital devices), and mainly the relationship between each other, in this way: People to Machine (P2M); People to People (P2P) and Machine to Machine (M2M). The common element in all the relationships is the Process, it works in each combination. All, in order to create compatible's and proper network links. IoE opens a world of opportunities

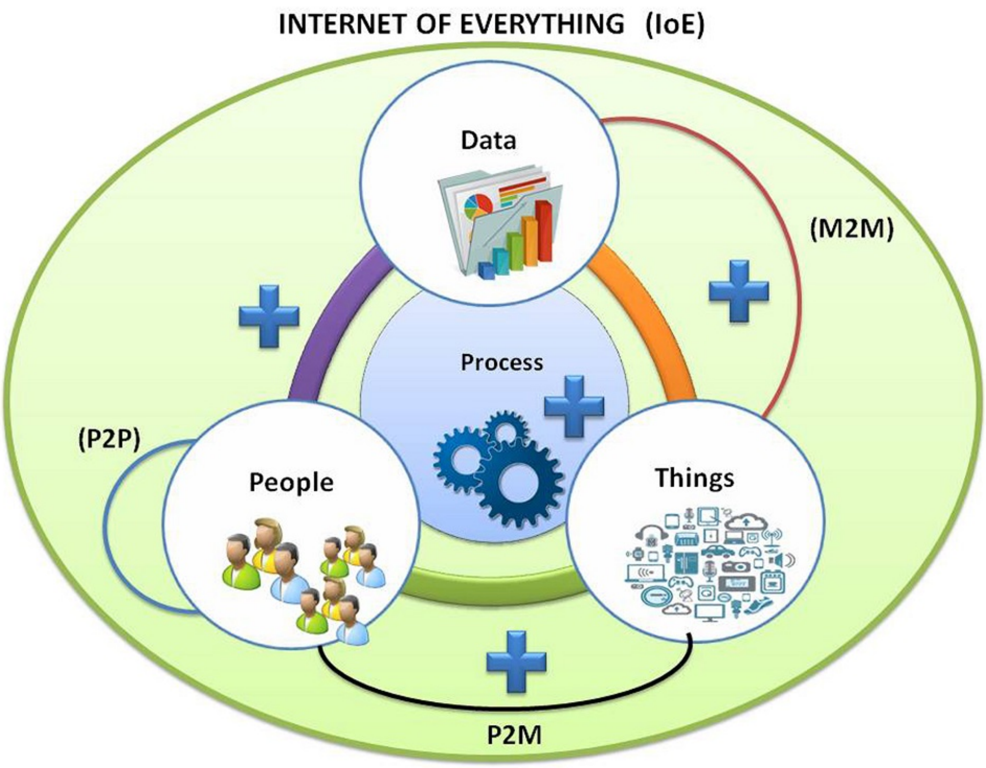


Fig. 4.2 The Internet of Everything (IoE)
Source: Image Adapted from Cisco

and setting up novel economic possibilities for persons, enterprises, and nations [121], [296], [188].

Fig. 4.2 shows in a graphical mode the IoE structure

Each element of the IoE and the relation between each other is explained as follow:

People

Citizens are online thanks to different digital devices such as personal computers, notebooks, laptops, cell phones (smartphones), etc., meanwhile, technology continues advancing and the form of connection is becoming more "personal.". People are considered as end-nodes connected to the internet to share information and activities. These includes, for instance, social networks, health and fitness sensors, among others [302].

For example, there are in progress many types of research in the health area in order to get valuable information from patients to help them in treatments and better to prevent risks wherever they are. This is the case of the Proteus pill, a sensor approved by the FDA, it is used mainly for knowing when people ingest or don't ingest their medicaments [121], [259].

From using sensors with dust size, until to arrive at the moment in which people can link to the Internet by their clothes and even though intimate articles like fragrances [121].

Things

Inert things such as sensors, devices, actuators, and other items providing and generating data or receiving information from other sources will help persons and equipment more and more to have a better performance. Almost all objects will become in the IoE, operative “participants”. [121], [302].

Data

Humans, computers, and digital devices create daily a lot of records (data), that can not be imagined. Thus, people could have in their hands "Knowledge" to manage. When these things became "smart" permit the computing, control, and decision process at the “edge” of the Internet. Existing in this mode a great change, since “dumb” data is transformed into “smart” information, moreover, this will allow the Internet to be more consistent, reliable and of course helpful [302], [121].

Process

Taking advantage of the connectivity among data, things and people to add value, here, the process performs a very important and vital paper in coordinating, how and if those entities are working or not together to transfer the correct information to the correct "smart" thing in a timely way on the network. The process is categorically required in this IoE approach. The process maintains objects working and sharing between each other in order to enhance and solve everyday problems [302], [121], [257].

4.5 IoT Main Components

From a high-level perspective, the IoT use for the implementation and function of successful IoT-based products and services the following components [188]:

4.5.1 Radio Frequency Identification (RFID)

Radio frequency identification (RFID) permit automatic identification and data capture using radio waves, a tag, and a reader. More data than traditional barcodes can be stored in the tag.

It contains data in the form of Electronic Product Code (EPC), a global RFID-based item identification system developed by the Auto-ID Center [147], [18].

In the market, three types of tags are used. The Passive RFID tags have not battery-powered. Applications of these type are in supply chains, passports, electronic tolls, and item-level tracking, in delivering and also in entry operations systems [147], [18]. Active RFID tags possess themselves a battery supply and for this reason, they can instigate communication with a reader. This type of tags can contain external sensors to monitor temperature, pressure, chemicals, and other external conditions. Semi-passive RFID tags use batteries to power the microchip while communicating by drawing power from the reader. With these considerations, it is possible to say that Active and Semi-passive RFID tags cost more than Passive tags [188], [147], [313].

4.5.2 Wireless Sensor Networks (WSN)

WSN permit distinct network topologies and multihop communication. WSN are devices formed of many smart sensors in order to monitor physical or environmental conditions; allowing the compilation, treatment, reviewing and distribution of important information. WSN are able to collaborate with RFID structures to get the best control of the objects' conditions [18].

Breakthrough Technologies on regards to low-power integrated circuits and wireless communications are now affordable, economic and permit the miniaturization of different objects for utilization in WSN applications. [188], [147].

4.5.3 Middleware

Middleware is considered a software layer inserted between applications of software to facilitate communication and the input / output for application creators. Middleware got its reputation in the 1980s thanks to its function in abbreviating the unification of existing technology with other most recent [188].

It is a mechanism to combine cyber-infrastructure with a Service Oriented Architecture (SOA) [147]. Its characteristic, of does not show the inside information of the diverse technology is important to IoT software creators, because, it liberates them from unnecessary software services, that are not related to a particular IoT application. It permits, in addition, the creation of novel utilities in the computing platform. Most middleware architectures ensure a service-oriented approach in order to support an unknown and dynamic network topology for the IoT [188].

4.5.4 Cloud Computing

The Cloud computing is a model for on-demand access to a shared set of configurable resources or applications from anywhere, it will allow supplying end-to-end service for enterprises and individual customers [188].

The IoT generates and needs an enormous amount of data, huge processing speed to enable real- time decision making, and high-speed. Cloud computing is capable of furnishing the virtual Infrastructure as a Service (IaaS) or Software as a Service (SaaS) [147], i.e. it combines different services inside as, monitor and control, storage repository, analytics tools, display platforms and customer delivery as an ideal back-end solution for handling those requirements [188], [254]. Fig. 4.3 has an example of the Cloud Computing infrastructure.

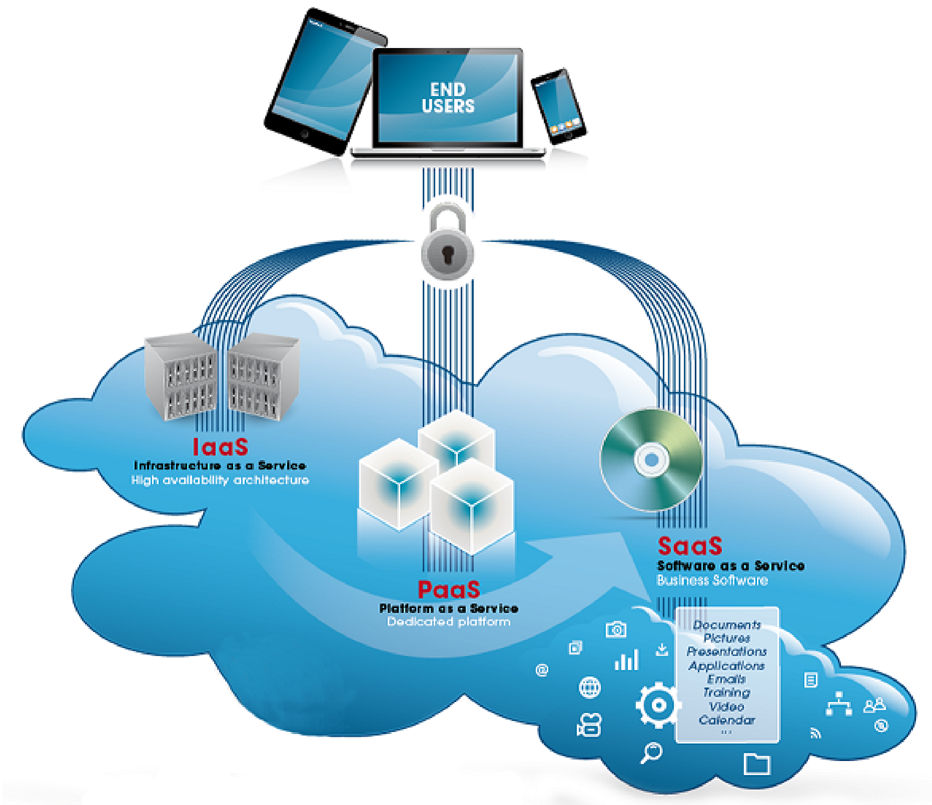


Fig. 4.3 Cloud Computing
Source:Adapted from: https://www.premaccess.com/hebergement-cloud-computing.html

4.5.5 IoT Applications

The IoT allows the implementation and development of several and multiple IoT applications directed to industry or specific users. While devices and networks permit physical connectivity, IoT applications enable device-to-device and human-to-device and device-to-device interactions it means People to People (P2P), People to Machine (P2M); and Machine to Machine (M2M) in a reliable and robust way [295], [296].

IoT applications on devices have to be sure that data/messages have been delivered and acted upon properly in a timely manner. e.g. transportation and logistics applications monitor the status of transported goods such as fresh-cut produce, meat, and dairy products. For instance, FedEx uses SenseAware to keep tabs on the temperature, location, and other vital signs of a package [188].

While M2M applications do not necessarily require data visualization, most human-centered IoT applications supply visualization to show information to end users in an easy-to-understand way and to allow interaction with the environment. IoT applications need to be built with intelligence so devices can resolve a problem through monitoring the environment to identify problems, communicate with each other without human intervention required [188], [147].

4.5.6 Examples of Applications Areas

A variety of applications of Internet of Things are currently being developed because it represents the new worldwide trend. The growing interest in IoT technologies and applications is proportional to the initiatives arising worldwide. In the US, the American National Science Foundation (NSF) launched in 2008 a program on Cyber-Physical Systems [191], aimed at introducing systems able to merge computational and physical resources. The European Commission had launched an initiative on “Internet-Connected Objects”, with the aim of increasing the competitiveness of European industry [18].

The IoT application domains recognized by IERC are based on surveys and reports applied by experts [296], [259], [295].

The IoT applications cover the vision of a pervasive IoT and require “smart” environments in domains such as: Energy, Health, Building, Transportation, Industry and City (Lifestyle, Emergency, User interaction, Culture and tourism) [296]. There will be about 40 smart cities by 2025 [295].

For instance, the HYDRA (http://www.hydramiddleware.eu) European project developed a middleware oriented to the need of developers to incorporate heterogeneous physical devices into their applications by offering easy internet service and interfaces for controlling the physical devices. Such prevalent diffusion of research initiatives denotes the competitive and relevant advantages offered by IoT [212], [151].

Starting from Smart Homes/Smart Buildings (technologies helpful in reducing the consumption of resources) to Smart Cities (optimization of city infrastructures quality of life), from Environmental monitoring (real time control of natural phenomena and sharing of data) to Health-care (sensors for patients capable to control different conditions, for instance, human temperature, blood pressure, breathing and etc. to transmit data to distant health facilities) from Smart business/Inventory and product management (bio-sensor technologies controlling production processes) to Security and surveillance (Ambient sensors able to monitor the presence of dangerous chemicals) [212], [151].

See Fig. 4.4 as a summary of the majority of the application domains of the IoT

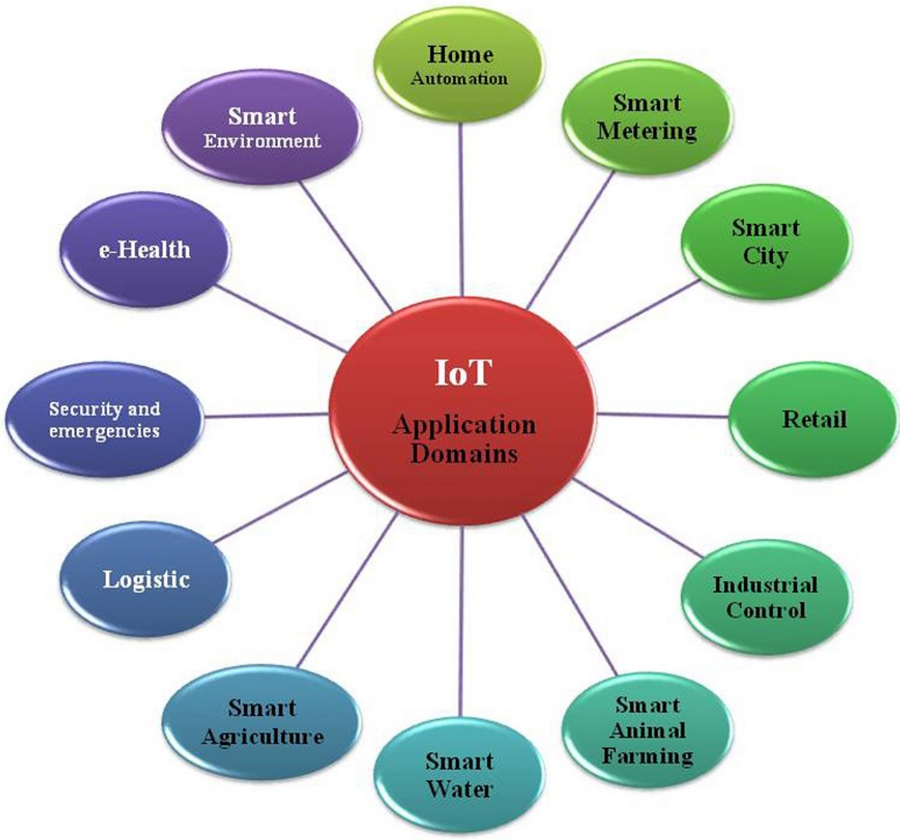


Fig. 4.4 Main IoT Application Domains
Source:Adapted from [237]

4.6 Smart City

The Smart City is a complex system, an ecosystem in which multiple agents interview and where many processes coexist and are linked each other. A Smart city uses TIC to made its infrastructure and public services more efficient and interactive [66]. The main focus of this newly coined term of “smart city” seems to be the key role played of ICT [189].

The smart cities initiatives started around 2009, at that time mayors and city managers were excited about adopting sensor technology. It was like a dream coming true, having the possibility to monitor air quality, traffic, noise. Sensors could help control services, to develop, and modernize urban areas. Municipalities attended carefully to the numerous Smart City advantages, and lower cost was a big driver [13], [202].

Research people predictions said than more than 60 percent of the world population expected to live in urban cities by 2025. Globally will be about 40 smart cities by 2025 [295].

It is considered a smart city when exists a vision of urban evolution that permit the integration of many different ICTs, keeping the security and privacy to manage the city's goods and services, it means, human, collective, and technological capital [11].

The main aim of developing a smart city is to enhance the life quality and the efficacy of the public services through the use of cutting-edge technology [189]. ICT allows to act in a direct way with the collectivity and the city facilities to control what events are occurring inside of the city in real time, thanks to the sensors installed with monitoring systems, here data are generated from the population and digital devices and then, are processed and analyzed to becoming into valuable information. This information will transform into knowledge and wisdom, that is the key to face inefficiency [219].

Furthermore, strategic plans for smart cities implementation and development are still in process and remain as abstract ideas because of the fact that those refer to a widely new interdisciplinary set of fields. ICT is adopted to improve quality and efficiency of city services, to decrease expenses and reserve consummation and to achieve better interaction between residents and government. So that, many smart city application are being developed to afford all above mentioned, in real time [189], [13].

The term 'Smart City' is used to denote the emerging cyber-physical ecosystem by deploying advanced communication infrastructures and novel services installed over the city. Using advanced services, it is possible to optimize the usage of physical city infrastructures (e.g., road networks, power grid, etc.) and life quality for its habitants. IoT technologies can find a number of diverse application in smart cities scenarios [212], [295], [296].

In this sense, a Smart City is which one that uses new information and communication technologies at the service of an urban collectivity leaned to review its own lifestyle to acquire a sustainable model of development [25].

Europe is called to become a pioneer in innovative projects on regards to the Smart Cities. The European Commission has devoted 365 million euros to initiatives related to smart cities and has contributed with more than 100 million euros for startups through grants under the formula of public-private partnerships [13].

Currently, three European cities: Barcelona, London, and Nice, lead the Forbes 2015 ranking of the five most Smart cities in the world.

Spain is the European country with most of the smart cities. It is not surprisingly that some cities as Santander, Coruña, Malaga, Barcelona and Madrid are leading very interesting projects of public networks that improve the quality of life of their citizens [13], [21]. See Fig. 4.5.

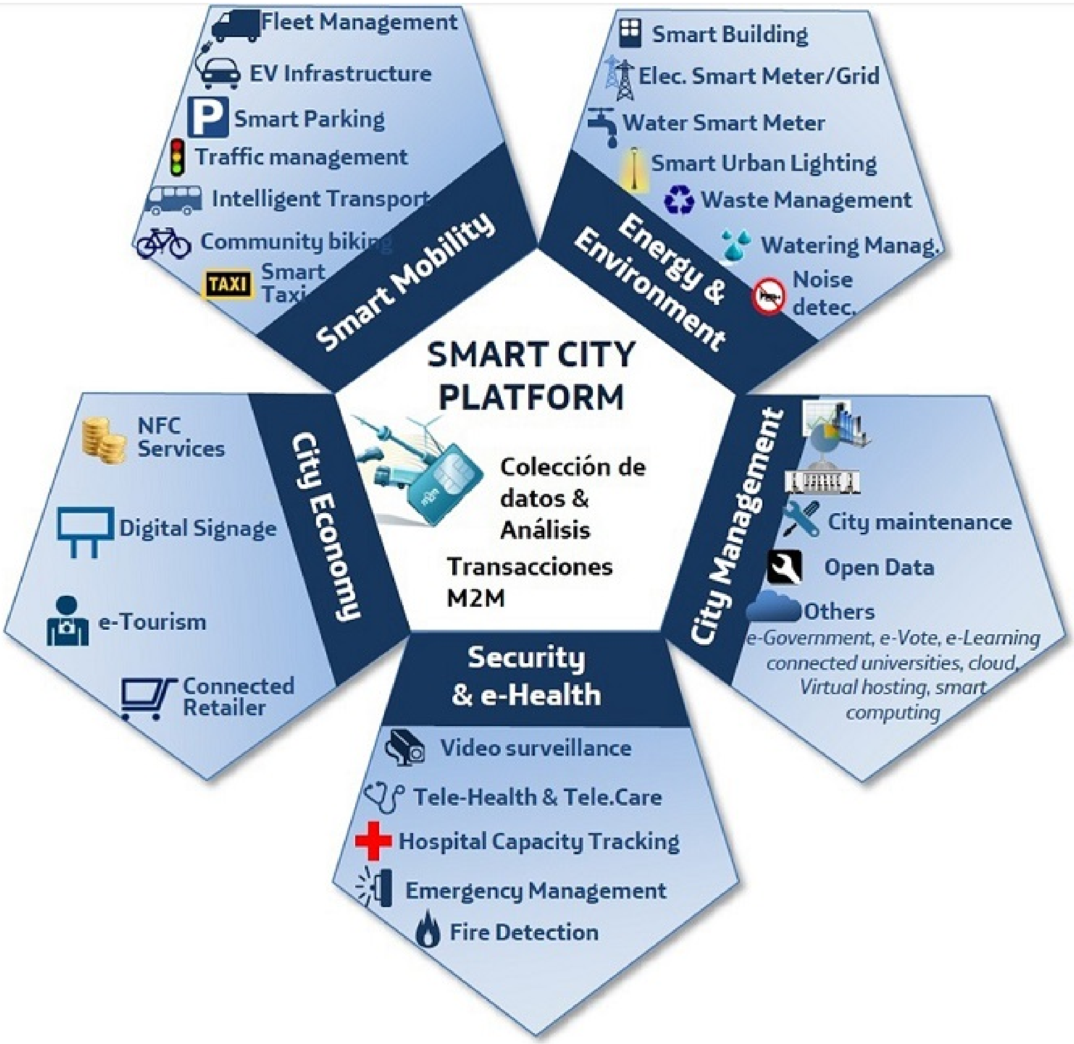


Fig. 4.5 Santander: Smart City vertical solutions
Source:Ayuntamiento de Santander [21]

The traditional isolated and vertical services generate inefficiencies and cost overruns in the management and operation of the elements that compose them.

Therefore a Smart City platform should provide the creation of a scalable and supported ecosystem of Smart City services, based on interoperable data solution. This platform should also manage efficiently the Smart City technology. All in the most efficient and sustainable way. This is possible through the emergence horizontal structures that eliminate inefficiencies and cost overruns [21], [13], [161].

Taking the same example of the Santander Smart City in Fig.4.5. It is possible to see a Horizontal Services based on IoT paradigm. See Fig. 4.6.

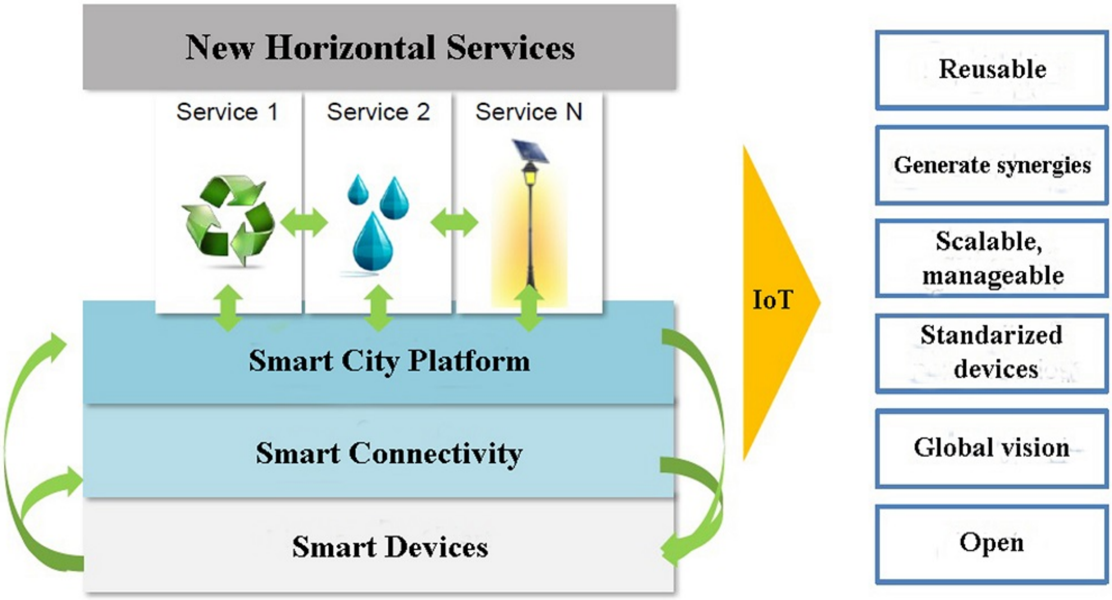


Fig. 4.6 Horizontal Structures of a Smart City - Santander's example
Source:Plan Director of Santander Smart City [21]

Smart Santander represents one of the first references of Smart Cities nowadays. Creating a unique European experimental facility for research and test of architectures, key enabling technologies, services and applications for the IoT [161].

The Smart City platform must provide a range of services to ensure the provision of the implemented services in the City. Such services and characteristics are represented in the following scheme in Fig. 4.7 [21], [161].

The Smart Cities initiative searches the city efficiency by managing data, information and ICT in order to supply qualified services to the population, motivating new investment projects between diverse profitable actors, taking advantage of the IoT paradigm [202], [209], [161], [13].

With this perspective, the model of a Smart World with a Smart City is represented in Fig. 4.8.

For a better understand of the graphic some details of the controlled things are presented according with several authors [295], [18], [188], [147], [151], [121], (www.libelium.com):

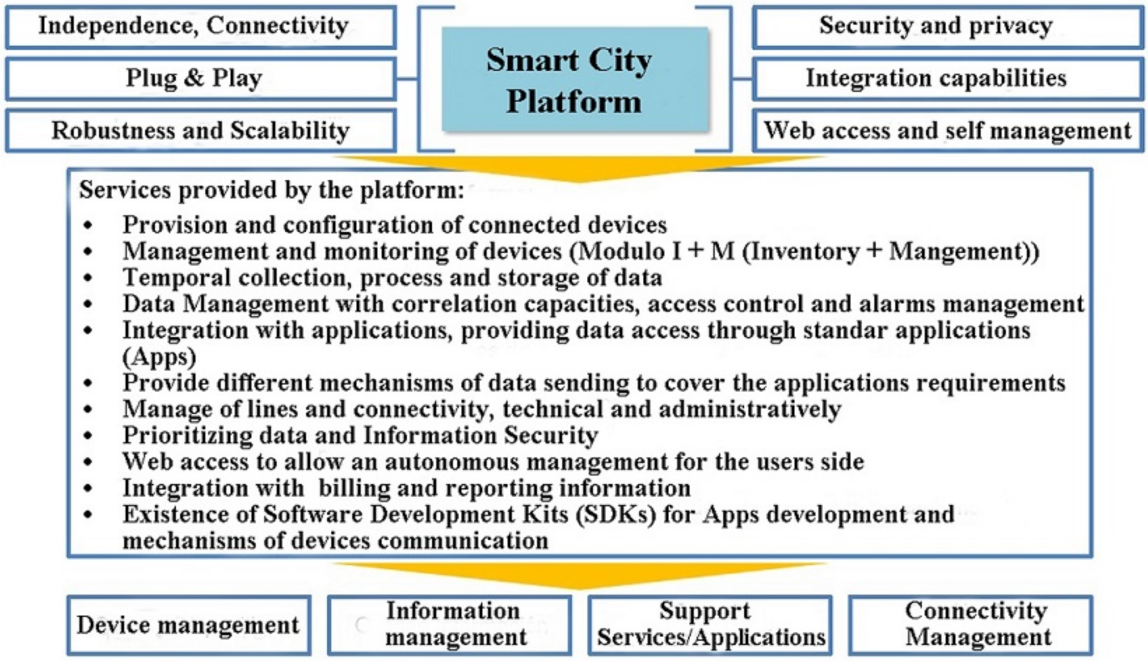


Fig. 4.7 Smart City basic Platform. Santander's example
A formal description of the horizontal Smart City Plataform of the Santander Smar City Plan
Source:Plan Director of Santander Smart City [21]

- **Air Pollution:** Control of CO_2 emissions of factories, pollution emitted by cars and toxic gasses generated by farms.
- **Forest Fire Detection:** Monitoring of Combustion gasses and possible fire conditions to define alert zones.
- **Farms Quality Enhancing:** Monitoring soil moisture and trunk diameter in farms to control the among of sugar in for instance this case grapes and grapevine health.
- **Offspring Care:** Control of growing conditions of the offspring in animal farms to ensure its survival and health.
- **Sportsmen Care:** Vital signs monitoring in high-performance centers and fields
- **Structural Health:** Monitoring of vibrations and material conditions in buildings, bridges, and historical monuments.
- **Smartphones Detection:** Detect iPhone and Android devices and in general any device which works with Wi-Fi or Bluetooth interfaces.

- **Perimeter Access Control:** Access control to restricted areas and detection of people in not – authorized areas.
- **Radiation Levels:** Distributed measurement of radiation levels in nuclear power stations surroundings to generate leakage alerts.
- **Electromagnetic Levels:** Measurement of the energy radiated by cell stations and Wi-Fi routers.
- **Traffic Congestion:** Monitoring of vehicles and pedestrian affluence to optimize driving and walking routes.
- **Smart Roads:** Warning messages and diversions according to climate conditions and unexpected events like accidents or jams.
- **Smart Lighting:** Intelligent and weather adaptive lighting in street lights.
- **Intelligent Shopping:** Getting advice at the point of sale according to customers habits, preferences, the presence of allergic components for them or expiring dates.
- **Noise Urban Maps:** Sound monitoring in bar areas and centric zones in real time.
- **Water Leakages:** Detection of liquid presence outside tank and pressure variations along pipes.
- **Vehicle Auto-diagnosis:** Information collection from WNS on the bus to send real-time alarms to emergencies or provide advice to drivers.
- **Item Location:** Search of individual items in big surfaces like warehouses o harbors.
- **Waste Management:** Detection of garbage levels in containers to optimize the trash collection routes.
- **Smart Parking:** Monitoring of parking spaces in the city
- **Golf Courses:** Selective irrigation en dry zones to reduce the water resource required in the green.
- **Water Quality:** Study of water suitability in rivers and the sea for fauna and eligibility for drinkable use.
- **Quality of Shipment Conditions:** Monitoring of vibrations, strokes, container openings or cold chain maintenance for insuring purposes.

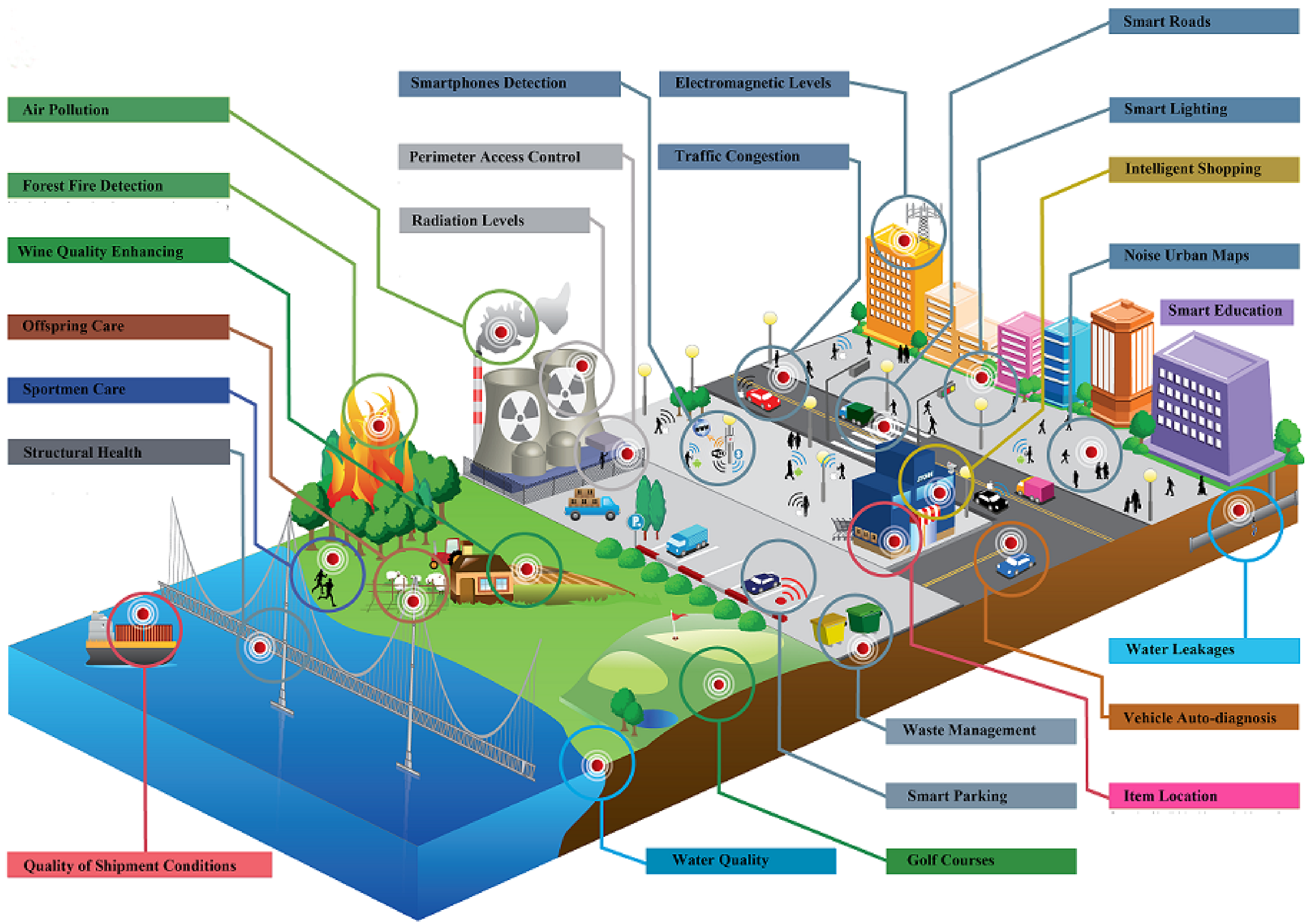


Fig. 4.8 Smart World with Smart Applications using the IoT paradigm
Source:Adapted from libelium.com company

4.7 New overviews and challenges of the technology

The cutting edge technology has been providing the market with even more available and relatively low-cost processing power, storage and battery capacity. This new tendency is allowing the development of extremely small-scale of electronic devices with communication, identification and computing capabilities [212].

The development of this new kind of facilities will need the introduction of novel paradigms and solutions of “anywhere, anytime and by anything”. New scenarios arise because of the IoT technologies. They will be gradually employed to existing ICT systems/applications, with new interaction functionalities. An important features is represented by the ability of sensing the environment and to self-organize into ad hoc networks, funding in this way solutions able to accommodate device’s heterogeneity and equipping sensor nodes with a battery (the need to replace batteries is a big deal (low power is a key goal)) [212], [151], [121].

Chapter 5

Computer Science at schools

"The number one benefit of information technology is that it empowers people to do what they want to do. It lets people be creative. It lets people be productive. It lets people learn things they didn't think they could learn before, and so in a sense, it is all about potential."

Steve Ballmer

5.1 Introduction

In the age of communication, technology is moving at an exponential speed and it is becoming progressively powerful and closer to final users [285], [51]. At the same time, each knowledge field has got some benefit from the internet and computer science [143].

With the technology industry growing more faster than any other area, there are fantastic opportunities for students to adopt prosperous careers in Information Technology (IT). What is more, almost every industry requires IT skills, due to the global adoption of the internet, websites, apps and IT programs in all sectors and particularly in business [210].

Many faculties, as well as parents, economists and politicians around the world, have started to think that students need some computing and coding skills. One of the principal reasons is the shortage of ICT-skilled employees: Schoolnet partnership for Europe, reports that by 2020, Europe may experience a scarcity of more than eight hundred thousand professionals skilled in informatics. In addition, coding skills help to understand today's digitalized society and foment 21st-century skills like creativity and critical thinking, problem-solving through communication and collaboration [23], [238].

Computer Science at schools has the goal of giving students vital 21st-Century Skills. These skills will fortify local and national innovation, and opportunities for young people. Computer Science underlies most innovation nowadays. Most of the schools require only that students use computers, but, the most important aim is to prepare students to innovate and create the new technologies that drive a digital economy. This competency to innovate with technology is also significant for students' future success and capacity to make a difference in a digital and global world [222], [23].

In the USA and developed countries computer science related jobs are the fastest growing and also highest paying, thus, computer science means also rewarding careers. It is important to mention that computer scientists also enjoy a wide range of career options since all industry areas today involve computing, so jobs are plentiful, interesting, and flexible [222].

In a general overview, Computer Science provides 21st-century skills necessary for innovation and translates to high-paying, in-demand jobs. Emphasizing that these skills could improve students' future opportunities. This kind of abilities take advantage of the interest of students in technology, helping them become technology innovators. Teachers can strongly help to build these skills, allowing students to design technical solutions to problems in all science sectors. Computer science can help educators better meet accountability goals of nowadays citizens [222], [15].

All this background has emphasized that digital competencies and skills are one of the main conditions for the success of digital transformation in the world. The challenge for Education sector is to empower young people with the competencies to master and create their own digital technologies and prosper in the society of today and at the same time to upskill the future workforce. And here is the importance of computer science at schools. [23], [15].

Youth should be formed in order to use the foundational principles of digital technology, not only in the application and use of it but also in how it works, because digital technology is everywhere [117], [176], [23].

Having this background as a premise, Computer Science at schools have to include the study of the foundations of computational phenomena i.e why and how programming languages work, the processes, and techniques that can be used to build new systems. [176], [23], [117].

Computer science has at its heart lies the notion of computational thinking [15].

Normally, the school focuses heavily on the use of computers and some ICT but fails absolutely in to study how they work, or their underlying principles. ICT is very important is like learning how to read; surely a skill that everyone should have. But is also necessary to learn how to write by engaging in the creative process of understanding, designing, and building new systems or applications (apps) [117], [176], [23].

Computer science as a rich discipline, on a par with Science, Engineering, and Mathematics. It is constructed on enduring principles, methods, and habits of mind. Through this complete science subject, students learn universal and comprehensive skills, such as problem-solving and abstraction, vital for the 21st century people [117], [176], [23], [15].

Computer science is a discipline because is characterized by [15] :

- A body of knowledge
- A set of techniques and methods that may be applied in the solution of problems and cases.
- A way of thinking and working
- Longevity: a discipline does not end lightly, even though the subject advances.
- Independence from determined technologies, particularly those that have a short shelf-life.

Computer science include [117], [23], [15], [238] :

- The study and development of algorithms and data structures (coding or programming): these are creative, systematic, efficient and effective ways to solve computational and daily problems, with a rich theory of the "complexity" each problem or case.
- An overview of computer systems and networks: e.g. how the internet works and the main protocols used to keep data flowing.
- A recognition of the challenges of human-computer interaction, which focuses on the challenge of making computers accessible to people.
- How computers work. In a traditional point of view, this means gates, binary arithmetic, and digital hardware. Having in account that computation paradigms are in rapid evolution.

In summary, "Computer Science is the quintessential STEM (Science, Technology, Engineering and Mathematics) subject" [176], [15].

5.2 "21st-Century Skills"

The expression "21st-Century skills" is widely used for more than one decade, and it is still no well development [113], [275], [252], [181].

The "21st-century skills" are an ensemble of intellectual capacities that students require acquire to be successful in the information era [232], [113].

In the USA, the Partnership for 21st Century Skills (P21) was one of the earliest groups to promote this paradigm in K-12 schools [113]. It was co-founded in 2002 by Ken Kay with the support of AOL (American OnLine, Internet and Media Company), Cisco, Microsoft, and the U.S. Department of Education, P21 triggered an United States conversation as it proposed a set of 21st-century students abilities as a basic framework [232], [275], [252], [181]. See Fig. 5.1.

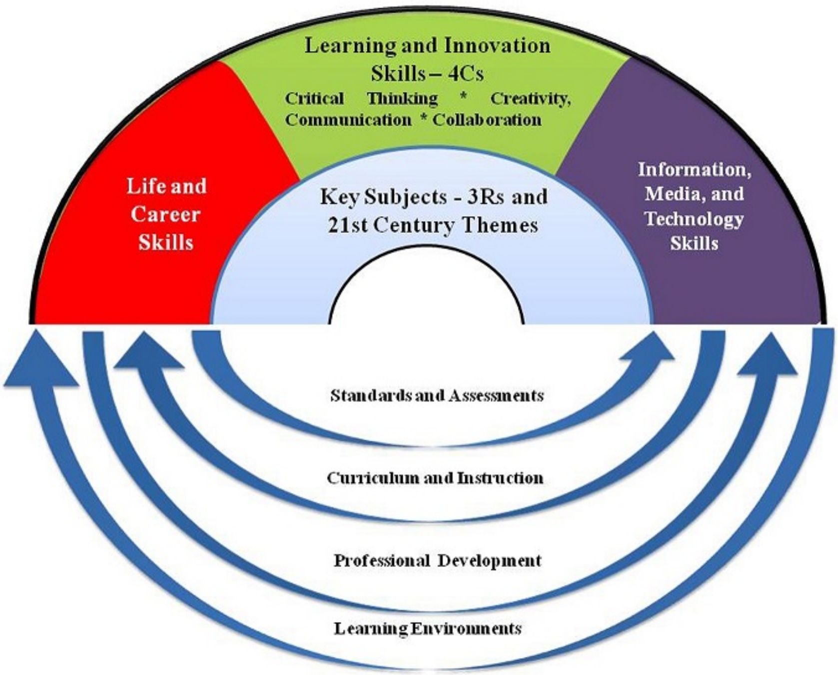


Fig. 5.1
P21's Framework for 21st Century Learning
Source: Adapted from: http://www.p21.org/Framework

The Partnership for 21st-Century Skills lists the next three general types [231]:

- Learning Skills
- Literacy Skills
- Life Skills

5.2.1 Learning Skills

The Learning and Innovation skills mark the difference between students who are ready for increasingly convoluted life and labor environments in the currently world and those who are not [231], [275], [181].

The 21st-century learning skills set contains the 4Cs (Critical Thinking and Problem Solving; Creativity and Innovation; Collaboration and, Communication): [57] [275], see for a better understanding Fig. 5.2.

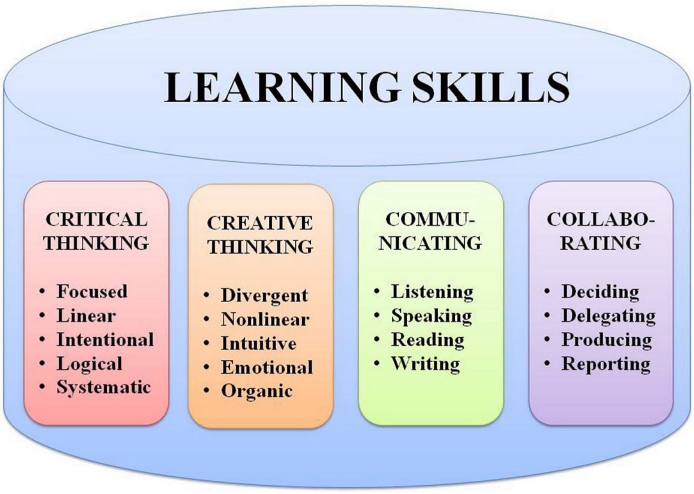


Fig. 5.2 Learning Skills

1) Critical Thinking and Problem Solving

Critical Thinking is produced when the reason is used to explore something. Thus, people is able to reason effectively in complex systems, to have criterions and to take decisions through an efficiently analysis, to resolve problems [181], [232].

2) Creativity and Innovation

Creative thinking is accomplished out when people is able to capture new ideas and possibilities. They think creatively, work creatively with others, People view any mistake as an occasion to acquire new knowledge and they implement Innovations as a tangible contribution in the field where are working [181], [232].

To get great thinkers is a process, where the Bloom's Taxonomy runs a fundamental role, this classification was designed and promoted by the educational psychologist Benjamin

Bloom in 1956. The terminology has been recently updated and identifies ever-deeper levels of critical and creative thinking summarized in Fig. 5.3

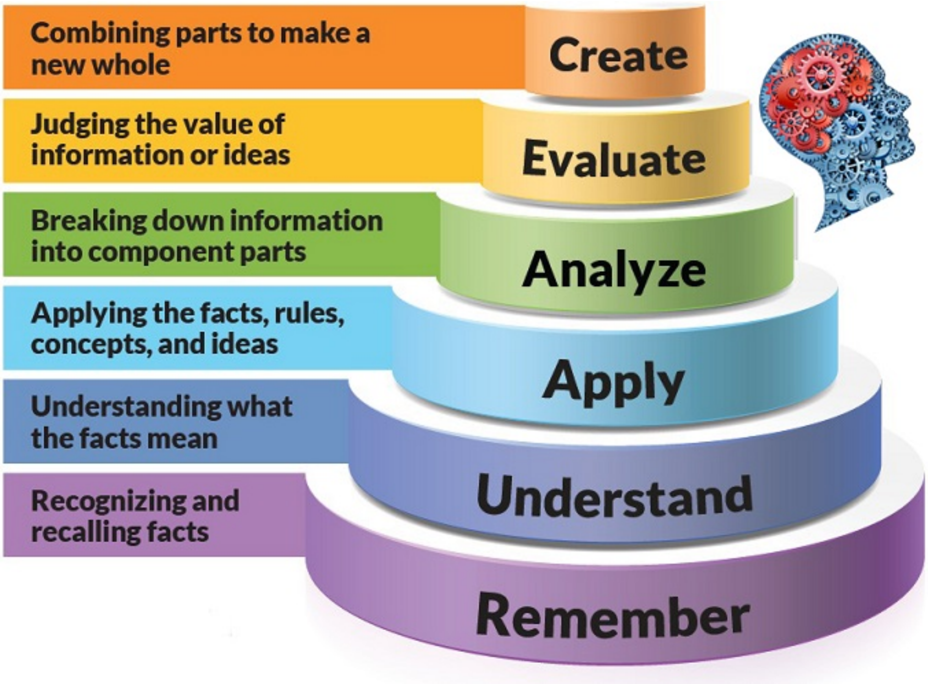


Fig. 5.3 Blooms Taxonomy levels. Source: University of Arkansas https://tips.uark.edu [282]

The learning skills use can be summarized in the following Fig 5.4.

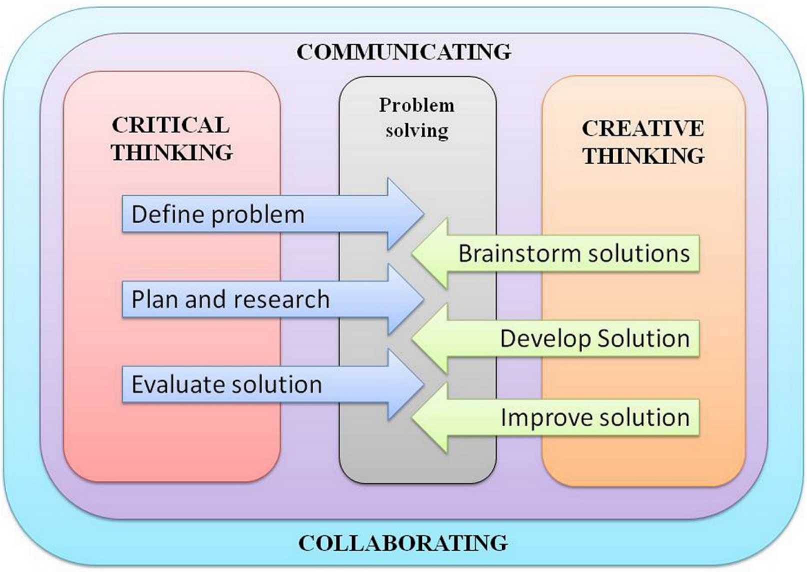


Fig. 5.4 Learning Skills use

3) Collaboration

Communicate clearly means to articulate and to listen thoughts and ideas effectively. It is also to use communication to inform, instruct, motivate and persuade, employing multiple media and technologies. All in diverse environments and languages [181], [232], [231].

4) Communication

Collaborating, that means to have the ability to work together as a team. In a practical way, it exercises flexibility and willingness to be helpful to obtain a common aim, assuming responsibilities and giving an added value at all the personal contributions [181], [232], [231].

5.2.2 Information, Media and Technology Skills

In the technological age, characterized by access to a very large quantity of information and fast changes in technology, the students and teachers abilities i.e. literacy skills to find, manage and use information, are required, in order to have success in school and life [181], [232], [231].

a) Information Literacy

Persons can access, use and manage information competently from a wide variety of sources, applying an ethical and legal behavior in the information use.

b) Media Literacy

Developing skills to analyze Media, to understand how multimedia information are constructed and with what intentions. Examining how people interpret data in diverse forms, and in what manner media has power on society. Applying ethical and legal use of the Media and being able to create Media products.

c) ICT literacy, Technology Literacy or Digital literacy

Subjects are able to apply and utilize communication/networking devices, applications and social networks effectively as tools to investigate, arrange, assess, produce and report information honestly in a digital economy where knowledge is the clue.

5.2.3 Life Skills

Nowadays, people needs thinking skills, knowledge (content), social and emotional abilities to manage complex work and life atmospheres, So that the 21st essential Life and Career Skills incorporate [181], [232], [231]:

a) Flexibility and adaptability

Adapt to change and be flexible. It means to understand, negotiation and balance diverse views and beliefs in multicultural environments to reach useful solutions.

b) Initiative and Self-Direction

Manage goals and time, work independently and be self-directed learners. Manifesting commitment to learn and explore opportunities to gain expertise.

c) Social and Cross-Cultural Skills

Interact and work effectively with others in diverse teams. Take advantage of social and cultural differences to develop new ideas for a high-quality work.

d) Productivity and Accountability

Manage and set projects during all the process, producing results with high quality. in conjunction with abilities as work positively and ethically with honor and integrity.

e) Leadership and Responsibility

Individuals can mentor and head groups, using problem-solving skills. Leveraging others strengths to accomplish a mutual aim, inspire others showing integrity and right conduct, acting responsibly with the community interests.

5.2.4 Key Subjects and 21st Century Themes

In the 21st-century, a domain of the key subjects is essential for all students. These themes include: English, reading or language arts; World languages; Arts; Mathematics; Economics; Science; Geography, History and Government and Civics [181], [232], [231].

Furthermore, schools must promote the application and understanding of academic content in higher levels of interdisciplinary and essential topics such as: [181], [232], [231].

- **Global Awareness:** Understanding other nations and cultures, including global issues and different languages.
- **Financial, Economic, Business and Entrepreneurial Literacy:**Understanding the special role of the economy in society, developing entrepreneurial skills for productivity.
- **Civic Literacy:** Being an active and participative citizen knowing and understanding governmental processes, duties, and rights.
- **Health Literacy:** Understanding basic health information, preventive health measures to make appropriate and safety decisions in health-related issues.
- **Environmental Literacy:** Understanding the impact of the society on the natural world. Taking individual or collective actions related to environmental issues

5.3 STEAM Education

Science, Technology, Engineering, Arts and Mathematics (STEAM) education (Fig. 5.5) was created to train teenagers with the high-tech skills necessary for the expanding STEAM job market [197].

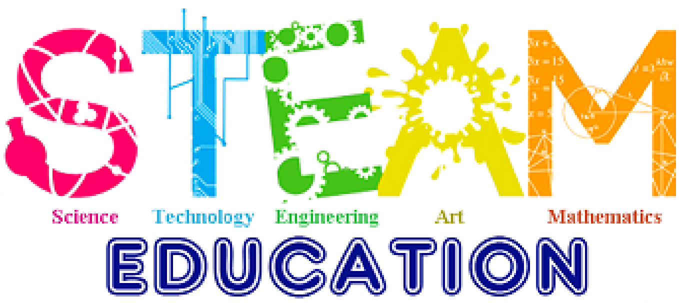


Fig. 5.5 Science, Technology, Engineering, Art, and Mathematics Education

STEAM is an education across the disciplines. Science and Technology understood by using mathematical notions and explained across engineering and the arts [263]. A detailed and graphical description of the STEAM education is given in Fig. 5.6

As regards to the STEAM education, several investigations are being carried out [187], with the creation of interactive virtual environments, encouraging the study of these disciplines with relevant results with the goal to help strengthen learning skills, developing the creativity in students of basic education for the resolution of problems and motivating

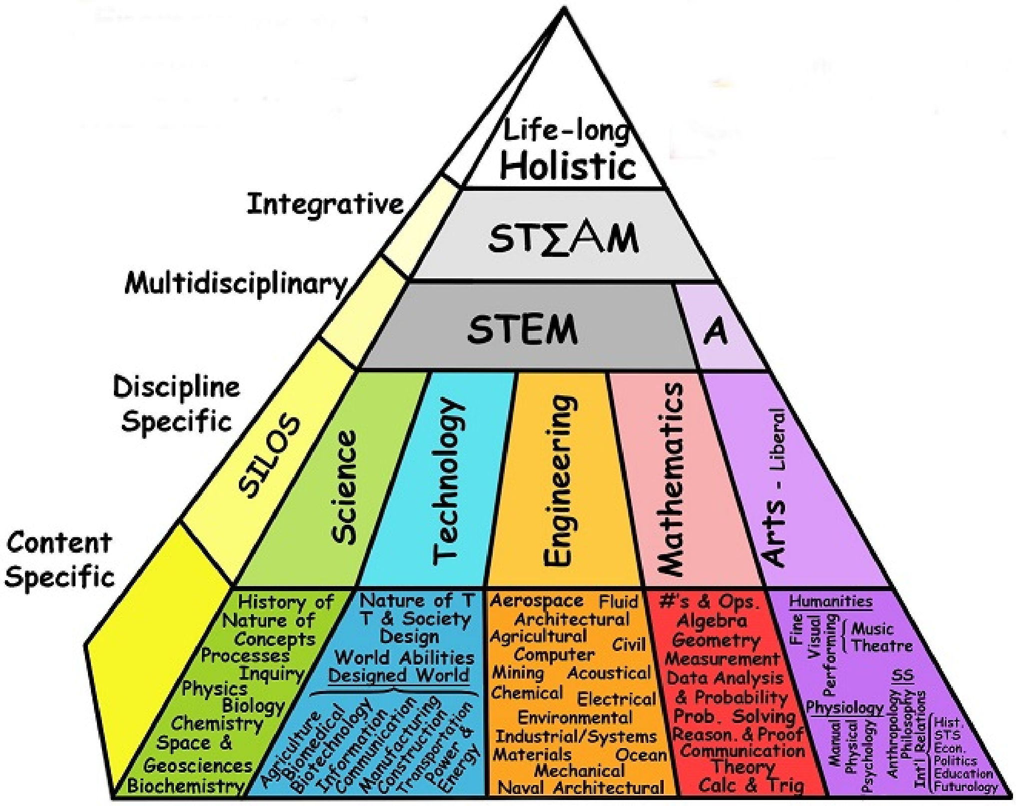


Fig. 5.6 STEAM Pyramide and disciplines. Source: http://steamedu.com/

since early childhood interest in areas of science and technology wanting to further explore a “STEAM” career.

5.4 Edutainments

The definition of Edutainment is given in Fig. 5.7, it is an education that is also entertainment.

In particular, this need of activating motivation has been significant for the acquirement and increase of young generation’s literacy and their interest in science, mainly focusing on the capacity of involving learners’ emotional-cognitive side through engaging science activities in an entertainment way. This kind of learning founded on engaging and amusing activities has been called “Edutainment”, thanks to blending both important aspects “education” and “entertainment” [54].

Fig. 5.7 Edutainment

5.5 Virtual Worlds

The Educational Virtual Worlds are considered as environments that allow continuum flexibility, personal experiences, different learning activities through several digital devices and promote the interactivity [285], [173].

Furthermore, these 3D virtual worlds permit to share and distribute information between participants, declining also the gap between experiential learning and theoretical learning [83], fostering innovative and novel educational opportunities for both, traditional classrooms and distance education [127], [106]. Besides, virtual worlds can be designed to manage individual learners' needs and interests [261], and be used by teachers or learners [45], [285].

In a usual way, in a virtual world, the user role is played by an avatar (character), controlled in real time by the user. Here exists a continuous interaction, it is the avatar who explores the world, meets other avatars, and participates in different activities as in real world [285].

Some output and input devices such as gloves, motion tracking systems, driving simulators and fliers gear levers can facilitate the interaction between users and computer [107], [36]. Also in education field [132], [160], [79], several virtual worlds have been implemented, taking into account digital natives' needs [112], [241], [243], [142]. In fact, many researchers have demonstrated that these kinds of systems are very effective in the teaching and learning process, and in particular in the study of difficult science topics [284], [46] or with students with special needs [34], [230].

An very important addition of using virtual worlds, is the possibility of fostering the users communication and collaboration [284].

The opportunity of feeling present in a nonmaterial world how is explained in [285] generates many different possibilities, that can be beneficial for educational objectives, that is why several researchers are working in this type of 3D virtual learning environments according to the technology advances and student's requirements [168], [178], [69], [153], [20].

Moreover, virtual learning environments provide interactive class materials [311], [206], [136], and others can transfer users into fabulous places of science where the learning became entertaining as the case of the Virtual environment in the Galápagos Islands [285], [284]. Besides all, thanks to virtual worlds potentialities, also knowledge acquisition and problem-solving skills increase, as well as the production and interchange of information through learning experiences [192], [125].

5.6 Project-based learning

Project-Based Learning (PBL) is an innovative and practical approach to learning. It teaches many and diverse strategies for success in the 21st century. In this approach are the students who lead their own learning through research, as well as teamwork that usually is collaborative to create and build projects that reflect their learning and knowledge, improving their technology skills, becoming in proficient thinkers and great problem solvers [28], [61].

5.7 Games in education and Game-Based Learning

Until the moment, a number of researches have been conducted regarding the efficacy of Game-Based Learning (GBL) in various areas such as business, math, statistics, computer science, biology, and psychology. It could increase the motivation of students for learning and afford them with opportunities to explore and acquire new knowledge and skills [246], [276], [155]

Definition 5.1 *Game-based learning (GBL) describes an environment where game content and gameplay enhance knowledge and skills acquisition, and where game activities involve problem-solving spaces and challenges that provide players/learners with a sense of achievement. [241], [246] (Prensky, 2001; Qian et al., 2016).*

Many researchers are involved in creating educational games to foster the acquirement of students' 21st-century skills.

Thanks to the fast growth of technology, computer games, and especially educational games or serious games, have proved the great potential for learning and training. Federation of American Scientists agrees computer games are helpful in developing higher-order skills such as multitasking, strategic thinking, problem-solving and decision making [276] [146], [68].

Prensky, for example, trusts that students are so attracted to games and computers, who use them to prepare for life in the 21st century, because they are learning about important "future" things, they pass from collaboration to cautious risk taking, to strategy formulation and execution, to complex moral and ethical decisions, important skills for great citizens [242], [243].

Furthermore, it is evident that digital games are becoming popular in the classroom. More teachers believe and confirm that games afford another instructional tool that is not only engaging, but also simulates hands on learning contextualized experiences [137].

For integrating games into the classroom different game genres can be used in several academic fields, distinctive pedagogical models, and with diverse strategies. Depending on the context, small-scale games can be used for quick demonstrations in the midst of a classroom lecture; others games might be deployed as central learning activities on one or more class periods [262].

In addition, games can operate as homework assignments, permitting students to work through challenges by themselves. Games also can be used as possible problems on a final test, using them in a concrete task or activity [262].

Over the years, digital games have assumed an important spot in the lives of students. They gain digital literacy informally, through play and schools do not take sufficient account of this significant aspect. It is prominent to consider that teachers need to realize that multimedia design for education in a global way, should blend the most potent features of interactive multimedia design with the most efficacious principles of technologically-mediated learning [146] [68].

Currently, it is evident that digital games are becoming popular in the classroom. More teachers believe and confirm that games afford another instructional tool that's not only engaging, but also simulates hands on learning contextualized experiences [137].

If games promote cooperation amongst participants and thereby, provide the environment for peer-to-peer learning and for the emergence of knowledge communities, where people can learn and also teach, [262], imagine how the outcome could be, when teachers or students plan, design, build and implement the games by themselves.

Games are a form to introduce students to the virtual worlds and the forms that they interact with technology may be changing ways of production of knowledge and learning [146], [155].

As Orson Scott Card, the science fiction writer prophesied, games have terrific educational potential. A helpful educational game can allow students to learn, teach and explore ideas in virtual environments [262].

Serious Games

Serious games environments are founded on constructivist approaches to promoting collaborative learning and active participation. Serious games build situated understandings. These promote social practices, strong identities and shared values and ways of thinking. Thus, games facilitate learning through challenging activities that engage the learners across gradually different levels of difficulty [90].

An important characteristic of serious games is, for instance, the mode by which educational content can be integrated with general game characteristics. With the constant use of the game, the learner is expected to get behaviors based on an affective or intellectual response which is the outcome from the active participation in the complete game [90].

5.8 Computational Thinking skills

The International Society for Technology in Education (ISTE) and the Computer Science Teachers Association (CSTA) have determined that Computational Thinking skills include: problem formulation, logical organization and data analysis, data representation through abstractions, the creation of computational automatic solutions, and problem generalization. As a result, they are a necessary prerequisite in digital society [309], and are critical to success [196].

In fact, they imply a new and fundamental way of thinking, involving the reflection on a problem, coding, designing, analyzing and applying some solutions to other contexts [196], [24].

The promotion of CT skills at all levels is one of the key goals to face the technological age. Several types of programming software are available depending on the age, level and results to obtain.

Regarding CT acquisition, various methods can be used to assess the acquired level of Computational Thinking concepts in order to detect differences and advancements among students of various ages. As an example, For instance, the "Progression of Early Computational Thinking model" [256] is very helpful to set age-appropriate curricula, and to define lesson plans targeted on students' cognitive development stage. Another meaningful example is Denner's criteria [105], based on the finite sequences of instructions used in Apps programming [104], [99].

As regards the arrangement of proper laboratories at University level, various works to introduce the general setting to promote coding had been carried out [286], [287].

In fact, to foster pre-service teachers' University training on Computational Thinking skills is fundamental for teaching at elementary school, where children can efficiently implement computer applications through the use of different software according to their level and age [27], being able to improve the following Computational Thinking dimensions: computational concepts (concepts that programmer use), computational practices (problem-solving practices that occurs in the process of programming), and computational perspectives (students' understanding of themselves, their relationships to others, and their technological context) [70].

5.9 FabLab (fabrication laboratory)

At the end of 20th century, researchers and educators started to consider the use of digital fabrication in education. Was the Stanford University on 2008 who launched the FabLab@School project, and began building FabLabs in K-12 schools around the world. According to Blikstein (2013), Dewey, Papert, and Freire are the theoretical pillars for Digital Fabrication and "Making" in Education all of them agreed to change the banking education into a creative, inventive and innovative education, with plenty knowledge of the real [60].

The most well known Fab Lab is the MIT's Center for Bits and Atoms an extension of its research within digital fabrication and computation, it was created in 2009. This Fab Lab is "a technical platform for innovation, invention, and encouragement of local entrepreneurship. A Fab Lab is also a platform for learning and innovation: a place to play, to create, to learn, to mentor and to invent. The main goal of a Fab lab is to connect with a global community of learners, educators, technologists, researchers, makers, and innovators. Creating in this way a knowledge sharing network" [214].

At the present time, Fab Labs are widely used for project-based, hands-on STEM education. Users in this platforms learn by creating things, of individual interest areas. Encouraged by themselves and applying the do-it-yourself DiY approach, users are able to learn and teach among participants, obtaining a great intellectual background about the equipment and materials used [122].

The mission of a Fab Lab is to provide access to the tools, the knowledge and the economical means to educate, innovate and invent using technology and digital fabrication to permit anyone to make almost everything, improving lives. The beneficiaries are education, organizational and services sectors and business [122].

In this manner, digital fabrication technology became better, more accessible more valued and important by the new technology. Digital fabrication and DiY approaches bring powerful ideas and tools to education. Today, the range of accepted disciplinary knowledge has expanded to include programming, engineering and design, everyday and everywhere is needed educational approaches that foster creativity and invention [60].

5.10 Contamination Lab concept

Contamination Labs (CLab) are physical and virtual spaces for sharing ideas and expertise to generate educational and creative experiences, bringing together the talent of university students, graduates, teachers, researchers and local entrepreneurs [278], [89].

CLabs are created to present students a stimulating environment for the development of an entrepreneurial vocation and encourage them to propose social innovation projects. Students with 21st-century skills in this places are able to take business risks, to get in start-ups and to be masters of their own present and future [278], [89].

5.11 Do-it-Yourself (DiY)

The phrase of "do-it-yourself" (DiY) has been related to consumers since around 1912, first of all, associated with home improvement activities and small construction projects [304].

From an academic research point of view, DiY is a behavior where subjects (using raw or semi-raw materials) produce, transform or reconstruct objects or make projects by several motivations, at the beginning these were categorized as marketplace motivations [306], [304].

Afterward, the term DiY has taken on a wide meaning with a wide range of skill sets. DIY is used in the military as a way to teach to take responsibility, and the ability to do things by themselves just as a preparation for their own life [304].

Approximately in the mid-1990s, DiY house-improvement started to appear onto the World Wide Web. Currently, DiY has exploded on the web [179].

There are DiY experiences from persons who have either built apps before or rely on it. Research has demonstrated that many factors motivate subjects to make their own assistive technology instead of buying it, those factors are for instance increased control over design elements, passion, and cost. DiY experiences in this new generation of rapid technology advances and online communities can empower more individuals to get into this approach [169].

5.12 Higher Order Thinking Skills

Higher Order Thinking Skills (HOTS), is a term of education reform based on learning taxonomies, such as Bloom's Taxonomy. HOTS concept says that some types of learning demand more cognitive processing than others having as a result more generalized benefits. In Bloom's taxonomy, (see section 5.2.1) for instance, skills including analysis, evaluation, and synthesis for the creation of new knowledge are considered to be of a higher order, requiring distinctive learning and teaching methods than the learning of facts [165]. HOTS involve the learning of complex skills such as critical thinking and problem solving. Higher order thinking is more difficult to learn or teach but also more significant because such skills are probably more usable in new situations [165], [315], [130].

5.13 Coding at schools

During last years, with the technological revolution, education has begun reformulating its perspective according to the new students requirements, who have to be qualified as successful subjects. Nevertheless, the majority of schools use technology or computers only to teach subjects in a traditional form and solely few give possibilities to learning coding or programming for students and teachers as mentioned [286], [287], [144].

The main reason for incorporating coding in school curricula is double: to equip all subjects with new abilities that are progressively observed as important in this digital society and well know as learning 21st-century skills, and to respond to the lack of IT-skilled people in Europe and in the world. As a result, coding has a prominent part in education [176], [15].

Especially for future teachers, there are not many possibilities to learn how to programming, however, currently the code is cataloged as a new language to share knowledge that does not need translation and that should be taught. Around the world, different initiatives are taking place, some are mentioned and explained in [286], [287], for instance, CoderDojos (https://coderdojo.org/) [91].

In Italy, the Education Ministry, after to see the booming experiences, carried out in the USA, has underlined the basic concepts of computer science at schools in order to cultivate the students' "Computational Thinking" abilities [286], [287] [206]. Thus, the education policy makers have published the Circular N°002937, "The Good School" related to the promotion and developed of the Higher Order Thinking Skills [286], [287] [165], [315], [130].

The specific aspects to achieving are:

- Digital literacy from primary school through coding,

- A program of "digital makers" for high school students, and
- Teacher training (for making possible the first two objectives.)

Respecting to the teacher's training the project Future Program started and a platform was implemented for Computer Science teachers and their students, by different levels (www.programmafuturo.it) [286], [287].

Chapter 6

Design of the "Smart Galápagos Islands": Learning Platform (S-GAL)

"Education is the most powerful weapon which you can use to change the world".

Nelson Mandela

6.1 Presentation of the "Smart Galápagos Islands": Learning Platform for Digital Economy, Fun, Innovation and Education (S-GAL)

As a Ph.D. student of the "Archimedes" School at the University of Calabria, I have participated in the research that led to the production of applications and surveys detailed as follow:

The design of the Smart Galápagos Islands Learning Platform for Digital Economy, Fun, Innovation and Education (S-GAL), a Platform based on all the newest technology trends and cutting-edge educational paradigms.

The original idea was to bring together all the stakeholders of education, it means students, teachers, parents and the community. But in addition including an important and innovative participation of researchers. Scientific people of all scientific sectors worried and involved in educational processes with the key goal of getting being humans with power skills to face the 21st-century and with a new spirit to change the world in a sustainable, responsible, and solidarity way.

In a first stage, with the Evolutionary System Group (ESG) as a research team, a 3D virtual environment was planned with the aim of training teachers as a clue of the educational system, thinking in a special manner in the Ecuadorian education.

Taking into account that, in Ecuador, the educative policy has changed but the application process has just started and is having a lot of problems, in one hand the lack of infrastructure and on the other hand, the national curriculum had stated that educational institutions should be encouraged to use technology in order to teach students the skills of the 21st century, this was one disagreement. Another divergence was that not all teachers or headmasters were inclined to use Information and Communication Technology (ICT) in class even if it was available [110]. The third discrepancy was that the use of technology at school did not seem to alter or enhance the pedagogical tools that teachers were using. The teachers, meanwhile, have increased interest towards these educational systems because of the potential and unique characteristics of them, but unfortunately also encounter difficulty in accessing, expanding and adapting these platforms with their content.

At Europe level, the Survey of Schools: even though teachers are familiar with the technology, they do not use ICT as often or just only to reproduce theoretical content [281].

So, the main goal of this research work was to respond to these requirements with the purpose of organizing a systematic work that could be used in Italy and also applied in Ecuador.

It is absolutely required the integration of ICT and the IoT in educational environments because society has changed from an industrial to an information or knowledge society. This big change presupposes that students need to be prepared for jobs that might not yet exist and being able to use ICT tools and IoT platforms are seen as two of the core competencies or skills for the 21st century [110].

The inspiration started thinking where? the already made and design 3D models could be placed, afterward, being Ecuadorian and wanting to promote a global research project with an attractive approach, the magic, and the delighted Galápagos Islands were mentioned, and many new ideas started taking place.

After a research process, some edutainments were planned, designed, developed and implemented step by step and in a continuous work process. The main characters are the Old and the Young Charles Darwin (Fig. 6.1).

6.2 Platform Design

The Smart Galápagos Islands Learning Platform as a whole was designed by parts but respecting the essential schema of a Systems Development Life Cycle (SDLC). Fig. 6.2.

Fig. 6.1 Main Characters of the Platform:
Old Charles Darwin and Young Darwin

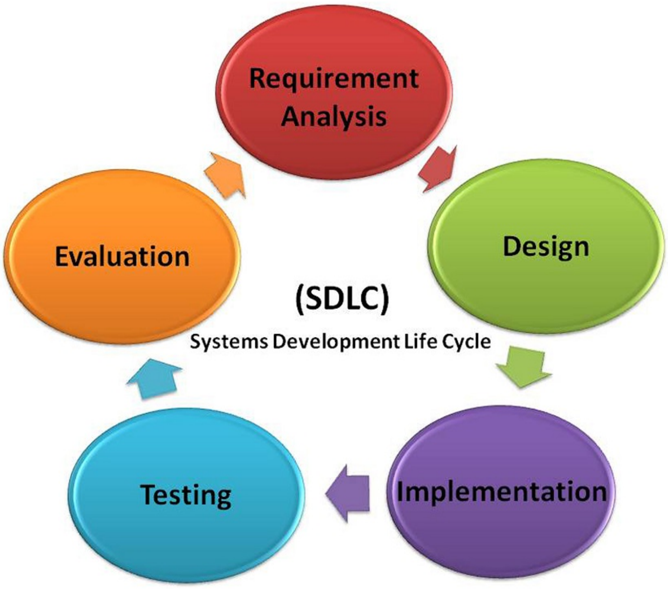


Fig. 6.2 Systems Development Life Cycle (SDLC)

The SDLC is composed by the entire process, step by step, to develop a system starting from the inquiry of users requirements or needs through analysis, design, implementation, testing and maintenance and finally deploying and evaluation [303],[58], [244].

Exists several models of SDLC such as the Fountain and the Spiral methodologies. One of the most known and used is the Waterfall model, it has a succession of stages in which the exit results of the prior step becomes the input for the following one [303],[58], [244].

These phases can be classified in different forms depending of the kind of system, as follows: see Fig. 6.3. [303],[58], [244]

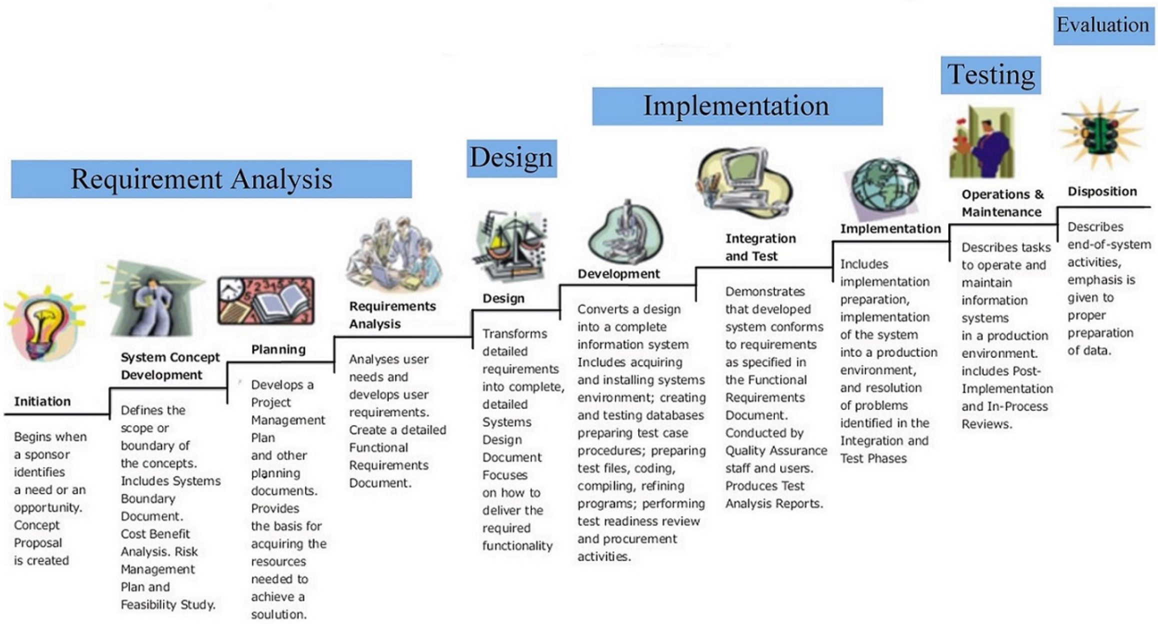


Fig. 6.3 Description of the phases of the Systems Development Life Cycle (SDLC)
Source: Adapted from https://commons.wikimedia.org/w/index.php?curid=5530145

For this specific platform the mentioned stages were followed and applied in each edutainment and application software.

6.2.1 Requirements analysis and System analysis

The importance of this step is fundamental, it defines which one is the big problem to solve. This means to establish in a general way first the expected project and define its aims, separating: the system in several parts to evaluate the each specific situation, the needs to be developed and bringing together also users. Afterward is possible to definite the requirements to solve the problem. Requirements are the most important fact of a success project [303],[58], [244].

During this research process, each study was deeply analyzed before to be carried out, as it is explained in Chapter 7.

6.2.2 Design

This stage describes in detail the features and operations desired.

Here, the requirements are the initial input identified in the approved requirements phase. It is necessary to be clear that for each need, more than one designs should be made as an outcome of investigation, in this case, interviews, and prototype attempts [303],[58], [244].

6.2.3 Implementation

The different scripts are written in this phase, modules or subsystem parts will be accomplished during this step and at the same time, unit testing and control are done in this phase, using for this specific platform different software detailed in the technical characteristics in section (6.3) [303],[58], [244].

6.2.4 Testing

Getting all the parts as a group into a trial environment then test, finding mistakes and interoperability function. The code modules are checked in different levels [303],[58], [244].

As for example: defect testing and performance testing are the most common tests in this phase [303],[58], [244].

6.2.5 Evaluation, Operations and Maintenance

Here, the system deployment incorporates modifications and enhancements before the decommissioning of the system. The system maintenance is a key factor of the SDLC [303], [58], [244].

In addition, during the rest of the life of the software: changes, correction, additions, migrate to a diverse platform and plus goes on evidently forever.

So, the waterfall model is well understood and used, but it does not work very well with systems for knowledge workers. Sadly, requirements increase and change and change across the time and procedure, that is why other models are used at the same time, for instance, the fountain model admits that several activities can not begin previous others also exists a substantial superposition of activities during the system development [303],[58], [244].

Meanwhile, the spiral method stresses the neediness to repeat previous steps several times at the same time that project advances.

But also it is real to consider that project is a set of abbreviated waterfall cycles, where each one gave as the outcome a small prototype, a part of the whole system [303],[58], [244].

6.2.6 Management and control

The SDLC stages supply a systematic guide to systems development and a resilient and constant form to arrange projects in order to match with the goal of the system. [303],[58], [244]. See. Fig.

During the design and development of the S-GAL platform, the management and control process were particularly continuous. See Fig. 6.4.

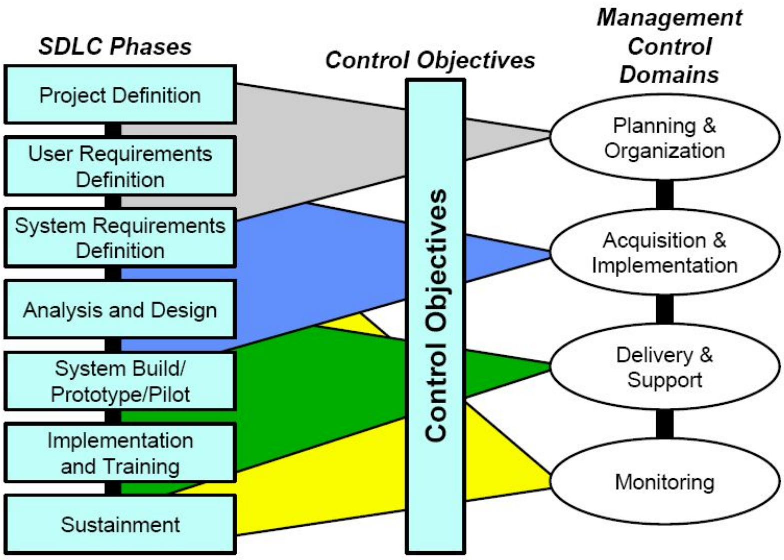


Fig. 6.4 Management and control process
Source: https://commons.wikimedia.org/w/index.php?curid=5061893[303]

6.3 Technical Characteristics of the Platform

The S-GAL has been development step by step according to the research process and requirements. Each developed work and study have been planned and organized systematically until to arrive at the macro system.

During this continued process several Software tools were used, in this section technical characteristics of the platform are presented (Fig. 6.5):

Unity 3D

Unity is used for creating 2D/3D games and interactive environments. Unity leads grandiose artistic power. It permits to improve the efficiency making the 3D hard work, more fun [279].

Unity works with the next programming languages:

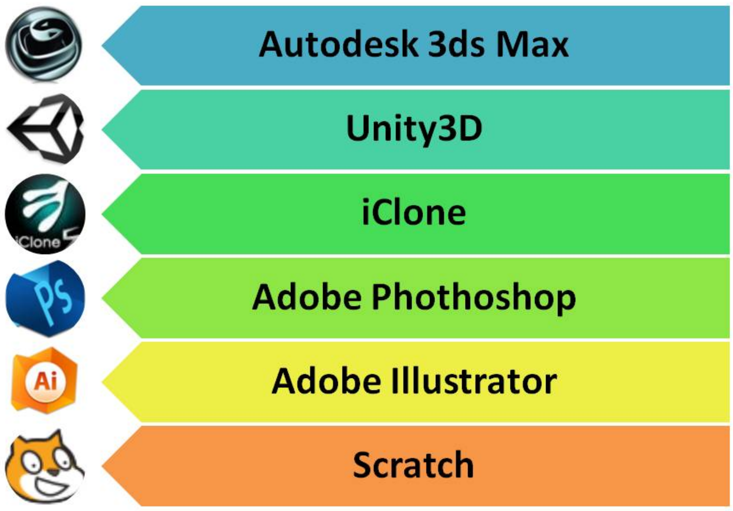


Fig. 6.5 Main Software used in this research

- C# (C Sharp): Based in the .Net Platform
- JavaScript: To made shorts, quick and practical scripts
- Boo: It is and implementation of Python.

Being Unity 3D a multiplatform, it was used for bringing together all the models, textures, figures, frames of the complete 3D environment of the Galápagos Islands through the corresponded scripts in each designed asset [279], [280].

Autodesk 3ds Max

Autodesk 3Ds Max was used for modelling, animation, simulation, and rendering each one of the objects in 3D virtual world in the Galápagos Islands [19].

Currently, Autodesk Education online program provides people and digital natives a way to think, plan, and draw whatever they want, because of the open entry to its design software. (http://www.autodesk.com/education/free-software/3ds-max).

Blender

Blender was used as an alternative free software for modeling [59]. It is a professional free and open-source 3D computer graphics software used for creating animated films, visual effects, art, 3D printed models, interactive 3D applications and video games.

iClone

iClone is a real-time 3D animation and rendering software program that permits to make 3D animated films. It was used for full facial and skeletal animation of human and animal figures as Darwin's avatar [170].

Adobe Photoshop

Adobe Photoshop is a raster graphics editor [4]. In Photoshop were edited the images used in the applications developed during this research.

Adobe Illustrator

Adobe Illustrator is a vector graphics editor. It was used to create illustrations, graphs, cartoons of real photographs [3]. Different scenarios were draft in Illustrator.

6.4 Scratch

Scratch is a visual software developed by the Lifelong Kindergarten Group at the MIT Media Lab [199]. This software is widely used by novice developers and lets programmers create customizable, media-rich projects online and offline according to the version used.

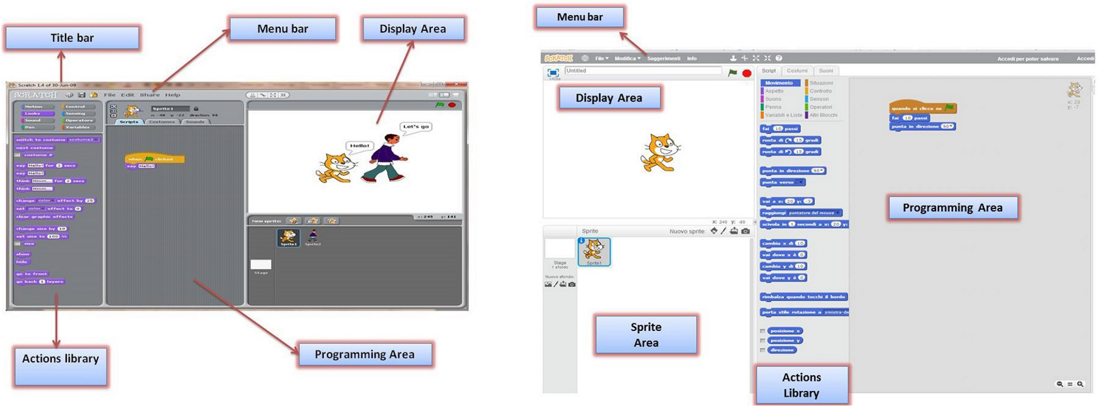
In the S-GAL Platform, Scratch was used mainly for both, to developing the game of Darwin traveling from Plymouth England to the Galápagos Islands and for the educational setting applied to Pre-service Teachers.

In next subsection, the main characteristics of Scratch software and function are analyzed.

6.4.1 Description of the Scratch software

In the Scratch website (https://scratch.mit.edu/), users are able to work (coding) and upload scripts or applications like games, tutorials, storybooks, cards for different occasions, music and art animations, science projects, simulations, tutorials. Working in the software, sounds, and figures can be directly imported, drawn or created using its paint implemented tool and sound recorder, currently exists also an option to use the webcam, transforming the interaction more diverse and creative [286], [287]. [248], [200].

The command blocks in Scratch are identified by colors (see Appendix B), designed to monitor and control all the several 2D components of each application; these 2D objects are known as “sprites”. These sprites can be moved and modified on a background known as



(a) Scratch interface version 1.4. [287] (b) Scratch interface version 2 [16]

Fig. 6.6 Scratch interface. Source: Vaca- Cárdenas et al., 2015 [286]

the stage or scenario. The sprites act as avatars and involve states (variables) and behaviors (scripts) [286], [287], [248], [200].

The blocks of commands function just on the object in which the script was built. It means that each sprite has its own self-contained group of scripts. The complete behavior and story of each sprite is narrated by the scripts [200]. The "drag and drop" approach is used by Scratch. The Stage size is 480 x 360 units. It is divided into an x-y coordinates [185]. See the Scratch interface in Fig. 6.6.

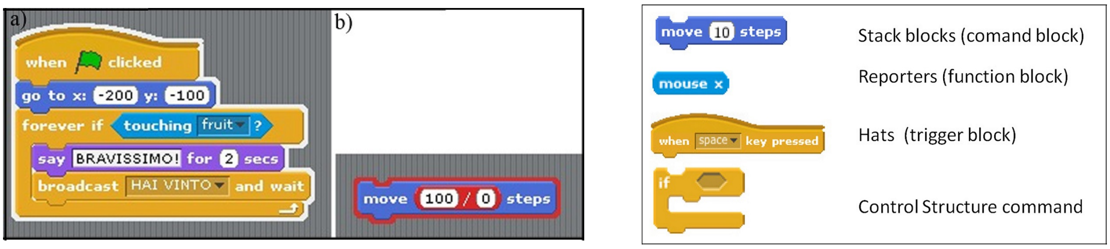
The coding activity is made through the use of the selected command blocks dragged from the blocks palette to the scripting area and putting together as puzzle parts, creating in this form stacks [285], [284], [199].

As it is explained in [286], [287], [285] [284] the sprites are the characters of the game.

Coding Environment

The software interface facilitates the surfing, Scratch has a single window where all constituent components are easily observable. Fig. 6.6a and Fig 6.6b show the interface of both Scratch versions.

The interface of both Scratch versions have 4 panels, in Vaca-Cárdenas et al.,[286] is explained in detail the interface of Scratch 1.4. The interface of the online and PC version 2.0 is divided in this way: in the upper left, the stage is located, here programmers can display the developed application and under it are settled all characters (sprites) of the project. In the center is located the blocks panel with the available categories and finally on the right side the scripting area in placed [287], [286].



(a) Testing blocks in Scratch

(b) Scratch blocks types. [200], [286]

Fig. 6.7 Blocks in Scratch. Source: Vaca- Cárdenas et al., 2015 [286]

For building scripts the blocks categories are always available, permitting users find them readily. See Appendix B (Scratch 1.4 blocks categories).

Scratch promotes tinkerability (it is the capacity to understand how to improvise, adapt, and iterate, changing old plans when new situations arise) encourages hands-on learning, remixing, and permits to build and assesses short scripts before to be assembled into larger units.

With a simple click is possible to test a stack of code as Fig 6.7a shows.

Syntax in Scratch

The syntax in Scratch is described through the existent blocks types and the use policy of them, that is also intuitive according with the command form. Fig. 6.7b gives a general idea of the four kinds of blocks in regards to their function. The description of each one is in [286] and [287].

Considering the form of the blocks, Scratch has three types of blocks: Stack Blocks (with notches on the top and/or bumps on the bottom). Hats (these have rounded tops and are always placed at the top of stacks, an event control their function). Reporters (These are designed to fit into other rectangular blocks)[185], [286] and [287]. Scratch has three data types boolean, number, and string [286] and [287].

6.5 The IoT approach in S-GAL Platform

The IoT in Education and e-Education

The educational challenge is one of the most worrying because the future work is to develop software and hardware for all devices and systems (standardization and compatibility) thinking in huge safety standards. The most requested profession will be engineers, programmers, security developers, and specialists in information technology. It is estimated by 2020, 4.5

million developers will be needed in the worldwide, working for this sector. However, a recent study highlighted that 20% of high school students never or almost never used a computer in class and the teacher training in new technologies is inadequate. The big question is Who will perform those tasks if education is not oriented towards them? [13].

Technology advances are forcing institutions to change their schemes and models in order to fit new challenges for education, due to the huge amount of available data, the exponential growth of knowledge and the consequent increase of competitiveness in the work area. Education has now to reconsider its model and grow into an active and participatory process, completely in relation with newer resources and with the nowadays students' requirements, that is what the "Smart Galápagos Islands" Platform for e-Education wants to offer.

This project could be in a future completely implemented through the Secretaria Nacional de Educación Superior, Ciencia, Tecnología e Innovación of Ecuador SENESCYT (National Secretary of Higher Education, Science, Technology, and Innovation of Ecuador).

The Smart Galápagos Islands platform wants to offer Infrastructure as a Service (Iaas) through the implementation of the network architecture, the Platform as a Service (PaaS), through application developers, and finally Software as a Service (SaaS) to final users, with the production of applications. See Fig. 6.8.

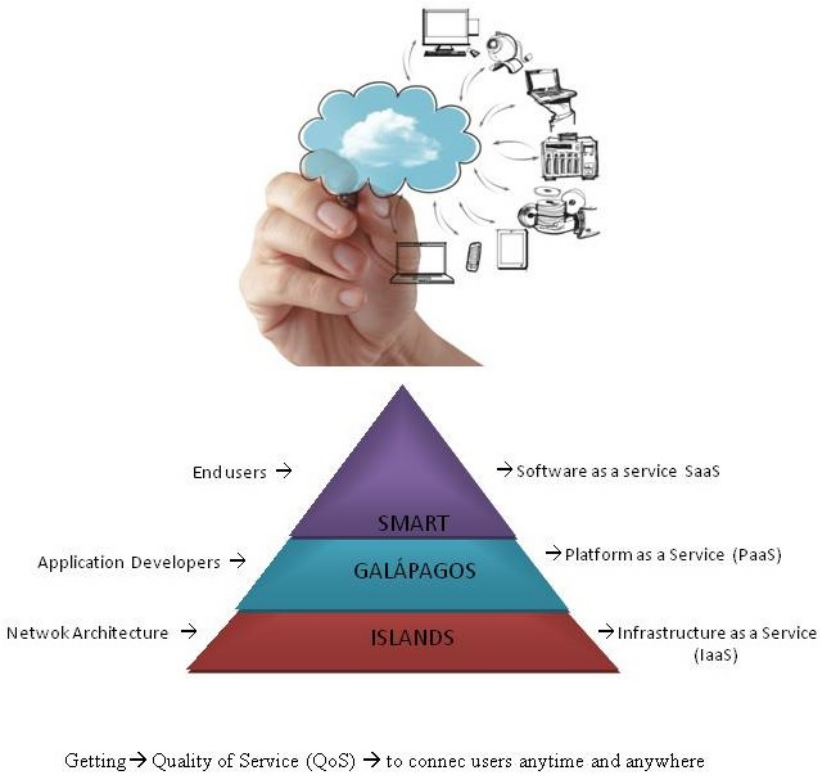


Fig. 6.8 Schema of the S-GAL services

All this services without forget to consider the learning pyramid adapted taking into account the 21st-century skills for learning already explained in Chapter 5. Focusing in a continuous collaborative learning. See Fig. 6.9

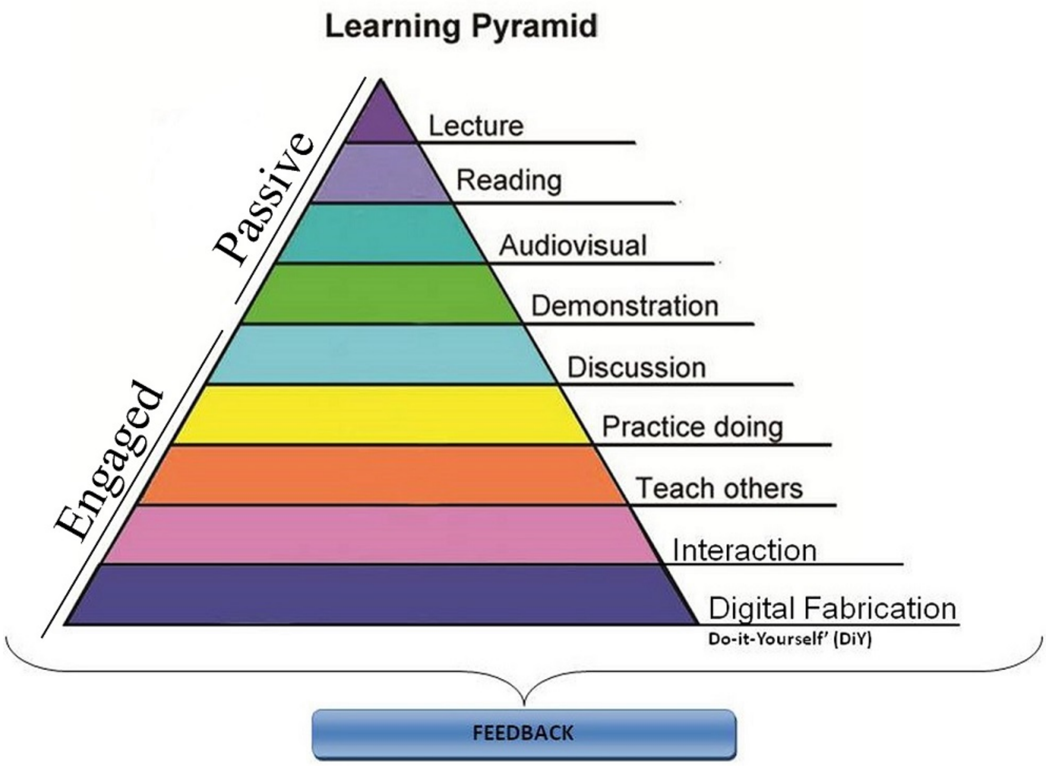


Fig. 6.9 Learning Pyrimid of S-GAL
Source: Image adapted from National Training Laboratories, Bethel Maine

The main architecture is detailed in Fig. 6.10.

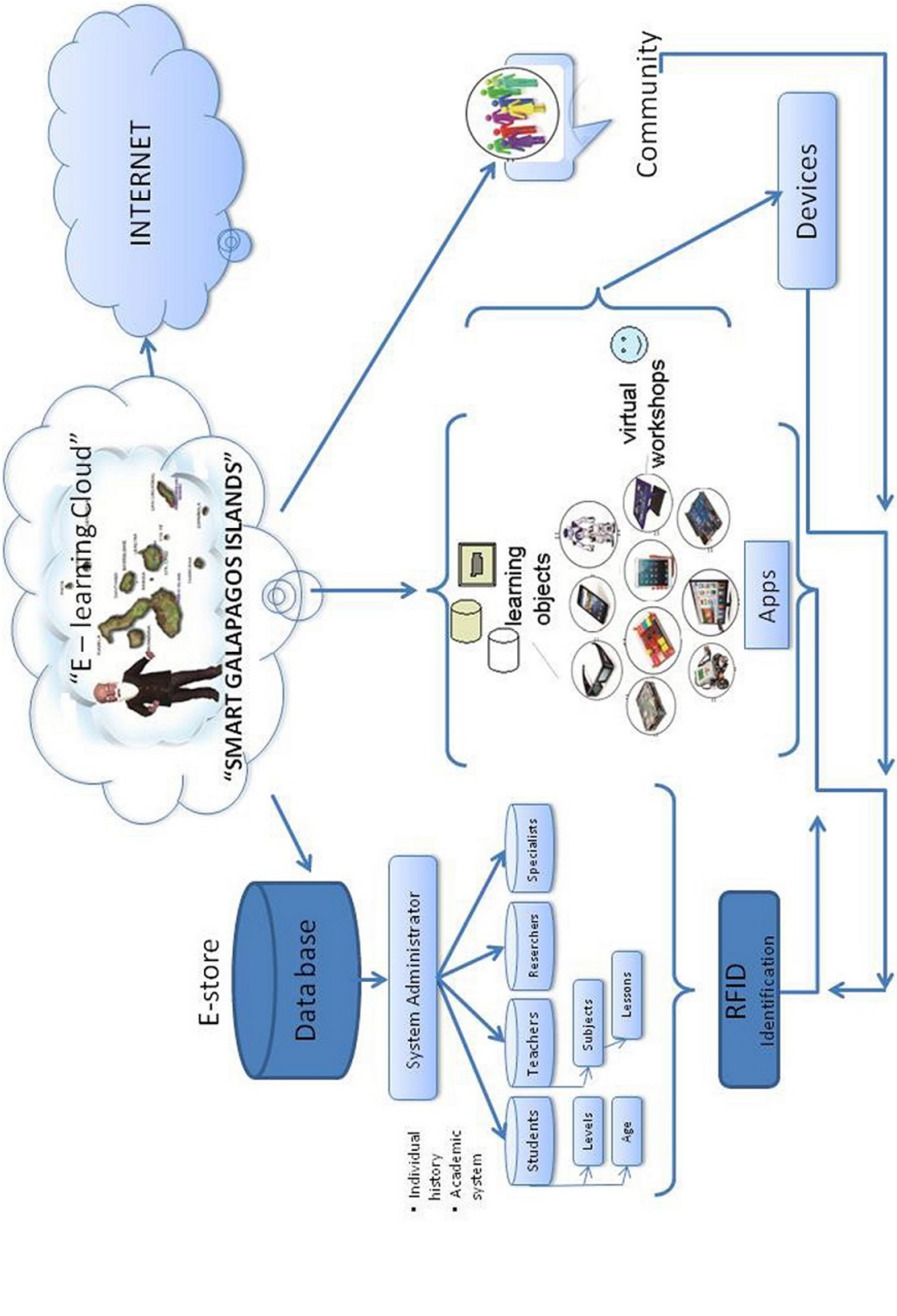


Fig. 6.10 Architecture of the Smart Galápagos Islands Platform

6.5.1 People

Global education is a goal for IoT in Education. The education becomes a possibility itself for every person who has access to the internet. People will become interconnected node inside this big platform that includes persons and contents, linked to real objects and many software applications, having the opportunity to build and development their own.

Students start being active learners, able to choose the topics and skills they are interested, due to the speed with which information is shared and acquired nowadays, allowing people to personalize and specify their learning needs and build connections not just with educational institutions, but also with peers and persons who share the same interests.

Experts teachers in a field of study will be able to teach anywhere, getting in touch with learners which are from every part of the world using different ways. In this field of great interests also for researchers, specialists or in general, persons interested in any information regarding scientific, technological and cultural training or support. In fact, anyone should be able to access in the system, after a proper identification (RFID in the future) that will give by the system administrator, for different educational, scientific purposes or curiosity.

6.5.2 Data

Data are essential in the "Smart Galápagos Islands" Platform and used as a dynamical entity. The connection makes the difference here: data communicate with all the other entities in the network, they are shared and continuously enriched by other data, subjects or processes. Students and Teachers will be able to access, monitor and collect data in real-time and from real objects, which will add authenticity to the topics studied, thus enhancing learning processes, becoming part of science communities in miscellanous investigation projects with the possibility of sharing datasets with people from different places in the planet, enhancing participants' learning experience. Researchers will be in touch with other scientific specialists to actively contribute to the growth of the educational network looking forward to solve local and global issues.

Learners become active students that applied the "learn by doing" and "do it yourself (DiY)" approaches. This Platform will become in a Big data ("Big data is a broad term for data sets so large or complex that traditional data processing applications are inadequate. Challenges include analysis, capture, search, sharing, storage, transfer, visualization, and information privacy") source looking forward to using it in many different research projects and applications.

6.5.3 Things

The global and ubiquitous connection of electronic devices and the frequent use that users make of them today allows the immediate exchange of information and unprecedented interaction. In IoT, this integrated connectivity is possible by incorporating semiconductors and sensors through which both people and the physical elements are able to communicate and provide more experiential information in order to make decisions and improve their functionality based on relevant and valuable data.

The field of education is a promising area where these devices are having a big impact because students are highly familiar with them, and, even use it as tools to support the learning due to the fast and fun assimilation of knowledge that they offer. Researchers and developers are actively working on learning systems where the integration between real objects and web-based information and learning will gain a deeper understanding in many disciplines.

6.5.4 Process

Thanks to the IoT, a flexible and sufficiently accessible architecture is available, that allows going beyond traditional applications. But, its performance becomes effectively at the time when users intend to access. To content them, it is necessary to have adequate optimization process favoring accuracy, speed, and quality of connections within the network.

One of the educational processes that is incorporated is the Contamination Lab, where concepts of 'Do-it-Yourself' (DIY) for the realization of wares are applied, also linked to the Opportunities provided by Open Technology and co-working. All these processes could be monitored through a Peer Tutoring system and Analysis Task approaches. In this way students are able to perform collaboratively without barriers of time and space, various learning activities and even access to the necessary tools to be available on the network to perform in their own homes the same activities and practices [224], [114], [211].

The main process is summarized in Fig. 6.11. The principal aim is to have an eEducation Platform based on IoT architecture, with the following processes used in the design phase:

1. Acquisition of data from the Students (name, age, level classification), Teachers (name, subjects, lessons, assessment activities) and physical available devices, possibly through mobile or interactive systems. These data will own an identifier, an IP address, or communications systems, and users will be able to realize activities (with a different kind of interaction for each user). A task analysis will also be carried out for users groups' activities. Everything will be stored in a Data Base.

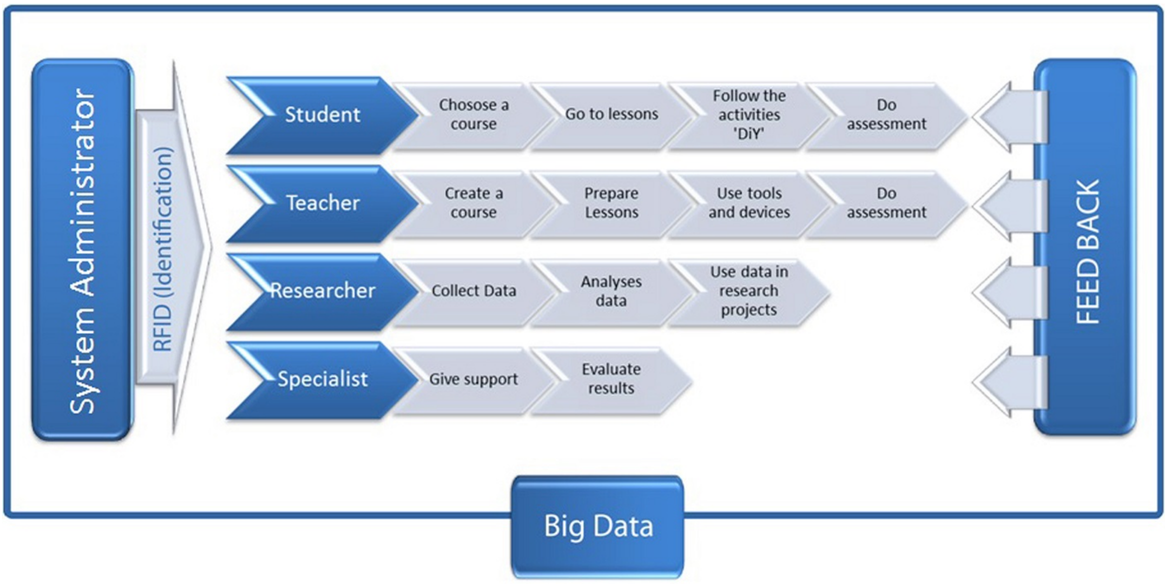


Fig. 6.11 Schema for an e-Education Platform based on the IoT and IoE

2. Organization of the system with the central role to the prosumers (i.e. consumers/producers of information), by developing a series of services ranging from e-Education to unconventional services, or entertainment systems for different users. Other services could be planned with the research and scientific team.

3. Development of usability systems and evolutionary projects, bearing in mind the need to adapt the complex organization of the system, through articulate processes of feedback acquisition by students. Big Data, which will be available for large-scale research.

In the education field we look forward:

- To develop cognitive capabilities and distributed decision-making.
- To promote the STEAM education approach improving learning skills, strengthening the ability to interpret and solve problems, and at the same time, developing creativity in the users.
- To learn by a multidisciplinary approach
- To get knowledge by an "unbound" virtual mobility world and with a constructivist approach, it means "learn by doing" and "Do it Yourself" (DiY).
- Networking and synergetic effect, etc.

The graphical IoT schema of the Smart Galápagos Islands is showed in Fig. 6.12.

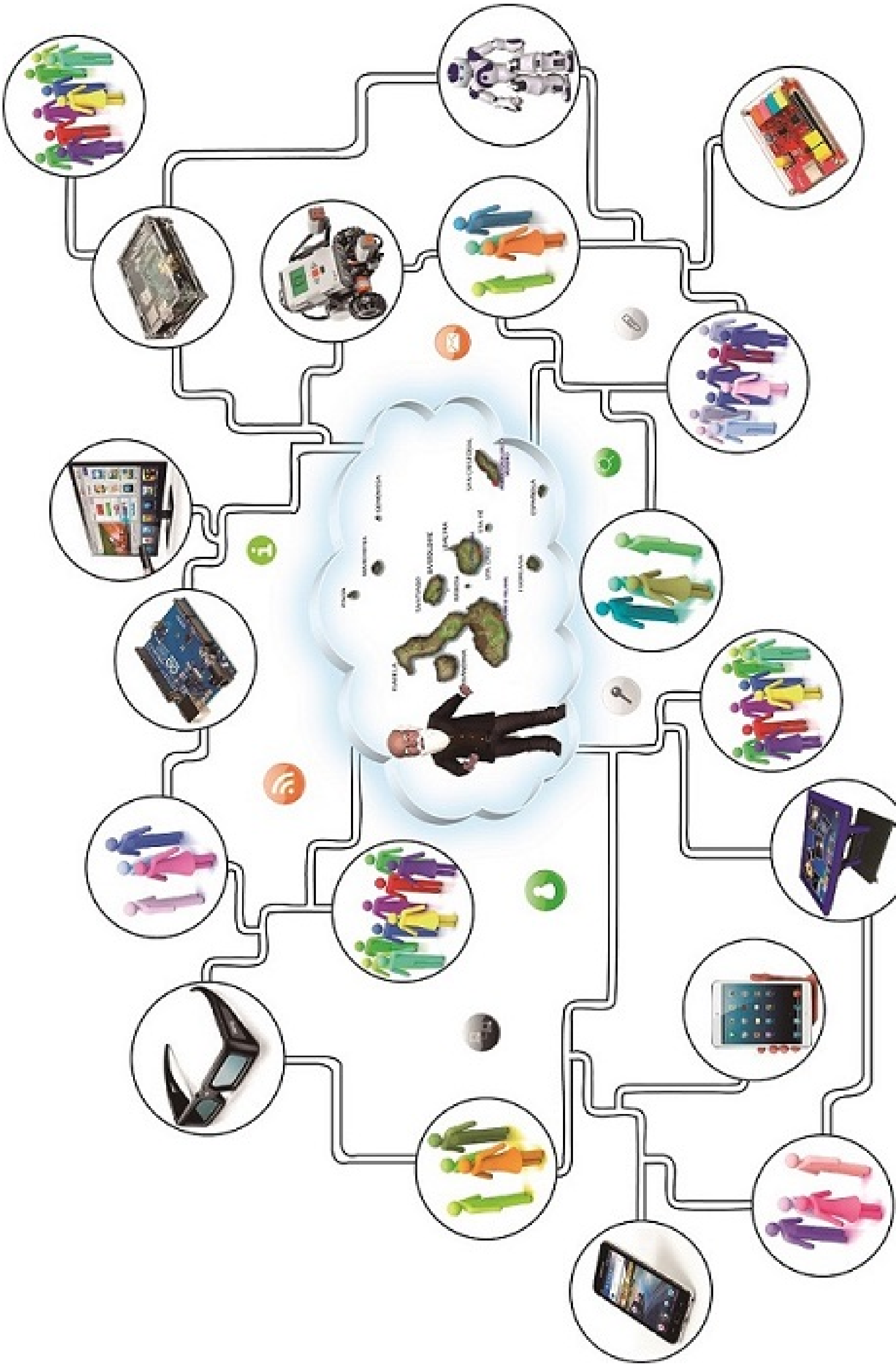


Fig. 6.12 The Smart Galápagos Islands IoT schema

6.6 Design of the Web Platform

Taking into account the IoT paradigm and with the ideal of taking advantage of the Internet service, a first draft of the website was designed, so everyone can access it, from anyplace at anytime.

The website home is showed in Fig. 6.13, it contains a main menu and general information: http://leticiavcecuador.wixsite.com/smartlearning

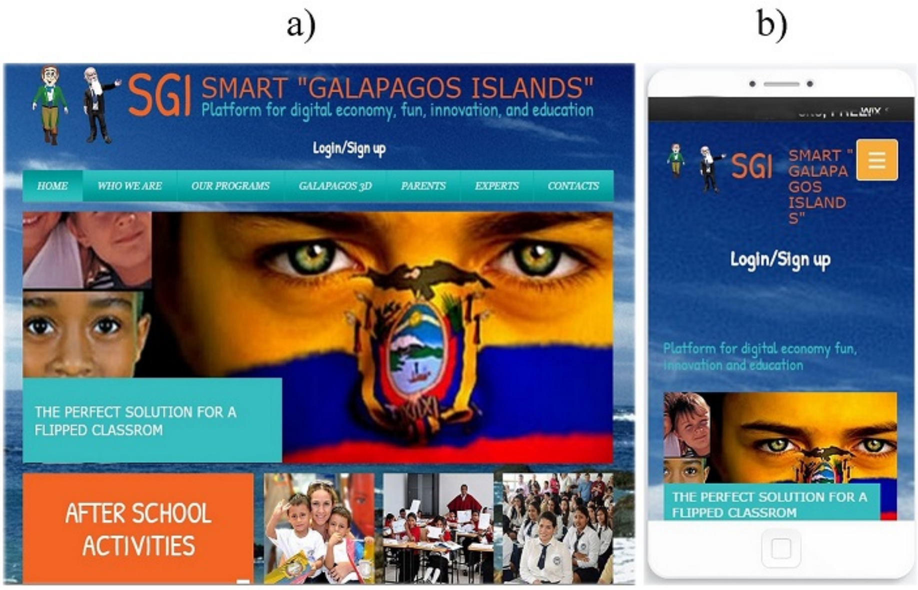


Fig. 6.13 Web Platform. First screen

The menu options are:

- **Home**: General presentation of the website
- **Who we are**: A brief description of the ESG research team, where the reseach process was carried out.
- **Our programs**: The setting of the "Coding with Scratch" is presented See Fig. 6.14. This option has a sub-option called **Coding with Scratch** here the different STEAM projects carried out by pre-service teachers will be presented. Only an example is showed. Fig. 6.15.
- **Galápagos 3D**: Here it is possible to enter in the 3D environment developed in Unity.
- **Parents**: A short description of the important role of parents in their children's education.

- **Experts**: Research especialists share their experiences in different areas. See Fig. 6.16
- **Contacts**: E-mail and phone information.

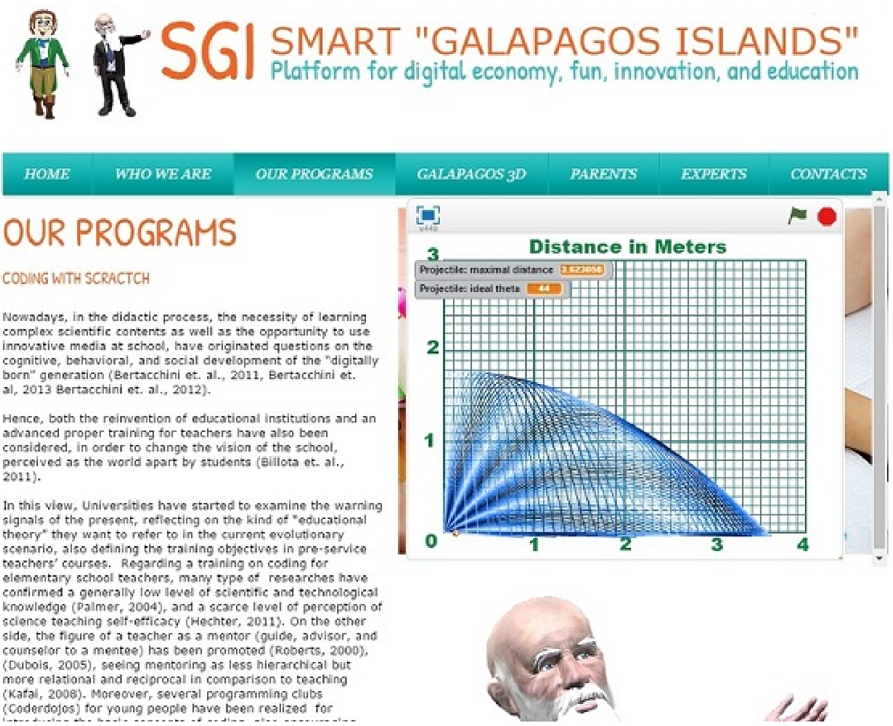


Fig. 6.14 Our Programs option

6.7 3D Virtual Scenarios in the Galápagos Islands

The Smart "Galápagos Islands" Learning Platform for Digital Economy, Fun, Innovation and Education is a web platform where the main studies and results carried out during this research will be presented.

This main web platform will be updated continuously with research results of the STEAM education proposed.

At the moment the designed project has a PC and a mobile version to be used online.

The Smart "Galápagos Islands" has inside a totally 3D environment inspired in the magic and delighted Galápagos Islands of Ecuador.

The 3D system was thought to promote the 21st-century skills and STEAM education.

As it was explained in Section 6.3. the main software used in the designed platform, now in this section the different 3D environments are presented some of them are not yet

Fig. 6.15 Scratch Projects for STEAM Education

Fig. 6.16 Experts option on the web

published and reported as research publication and constitute one of the most important parts of the design web prototype.

Most of the 3D environment and scenarios were designed and implemented in Unity 3D, All the designed pieces as the avatar of Darwin, 3d models, textures, objects developed on different graphic tools were brought together on the different Unity 3D scenes. It is important to say that thanks to Unity 3D, the 3D "Smart Galápagos Islands" is a multiplatform system, it can run in Windows, iOS, Linux, etc as the most popular operating systems.

Each scene is a scenario of the 3D system and has an approach innovative and unique. On the next screenshots each scenario will be presented and explained, with Darwin as the main avatar.

After to pass the first screen Fig. 6.17 and push the **Start** button (Fig. 6.18) a main menu will appear. Each button shows a different scenario also in each scenario a boat (simulating the Beagle) is a trigger to go back to the main menu Fig. 6.19.

Fig. 6.17 Galápagos Islands 3D environment. First screen

Fig. 6.18 Galápagos Islands 3D environment. Start screen

Fig. 6.19 Galápagos Islands 3D environment. Main menu

6.7.1 First Scenario: Charles Darwin Research Station

The Fig. 6.20 is an screenshot of the inside of the Charles Darwin Research Station.

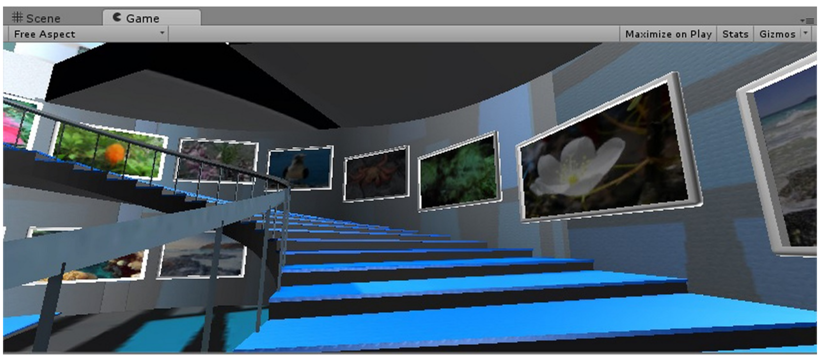


Fig. 6.20 Charles Darwin Research Station Scenario. View 1

In this scenario a tour for the lighted and magic flora and fauna of the Galápagos Islands can be appreciated around this research station.

Inside of this station, it is possible to watch some wonderful species never seen before around the world. Users are able to see 29 pictures placed on the museum walls and 12 posters located on the second floor of the scenario and placed over 12 poster containers pretty placed thanks to some Unity 3D effects.

See also Figs. 6.21, 6.22, and in Appendix C, Figs. C.2, C.3,

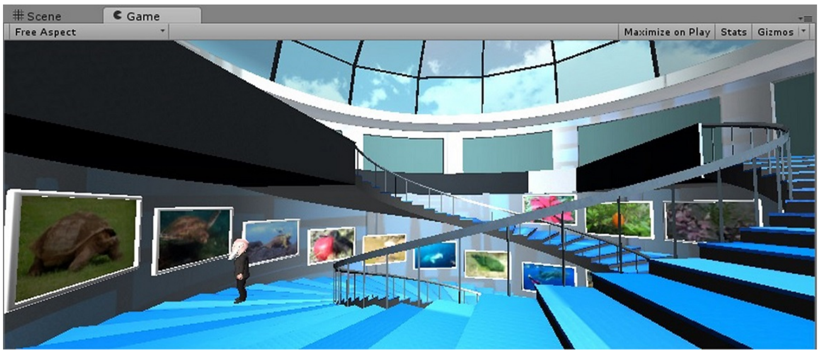


Fig. 6.21 Charles Darwin Research Station Scenario. View 2

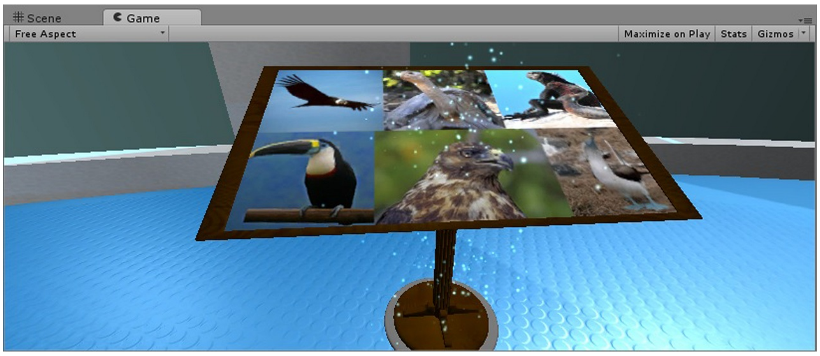


Fig. 6.22 Charles Darwin Research Station Scenario. Poster view

Finally, it is possible to appreciate in Fig. C.4 (in Appendix C) the trigger object, that for all scenes in the 3D environment, is the boat. It represents the well known "Beagle", following the metaphor of Darwin's journey. See also Appendix C to admire more scenes views.

6.7.2 Second Scenario: Coding with Scratch Island

Inside of this scenario, users find a room similar a museum where ancient objects are located, but also two big frames with the main screens of the Darwin's scratch game. There are also scratch cubes located around, these are trigger elements that will permit users to open a Scratch application, but also in the web player version due to the conection existed with the MIT website through code included.

See Figs 6.23, 6.24.

Fig. 6.23 Galápagos Islands 3D environment. Scratch Scenario

Fig. 6.24 Scratch Scenario triggers

6.7.3 Third Scenario: Chaos Museum Island

The Bartolomé Island is the place where the Museum of the Chaos Theory is located. This scenario will be better explained in the next chapter because it was already published as part of a Edutainment [285].

Here a screen shot of the scene view Fig. 6.25

Fig. 6.25 Bartolomé Island with Chaos Museum

6.7.4 Fourth Scenario: History Island

Here an ancient Roman Theater developed by the ESG appears, Here Darwin is able to watch and heart a history dialog and also walk around watching posters of that time.

See Fig. 6.26, 6.27, and in Appendix C, Figs. C.8, C.9.

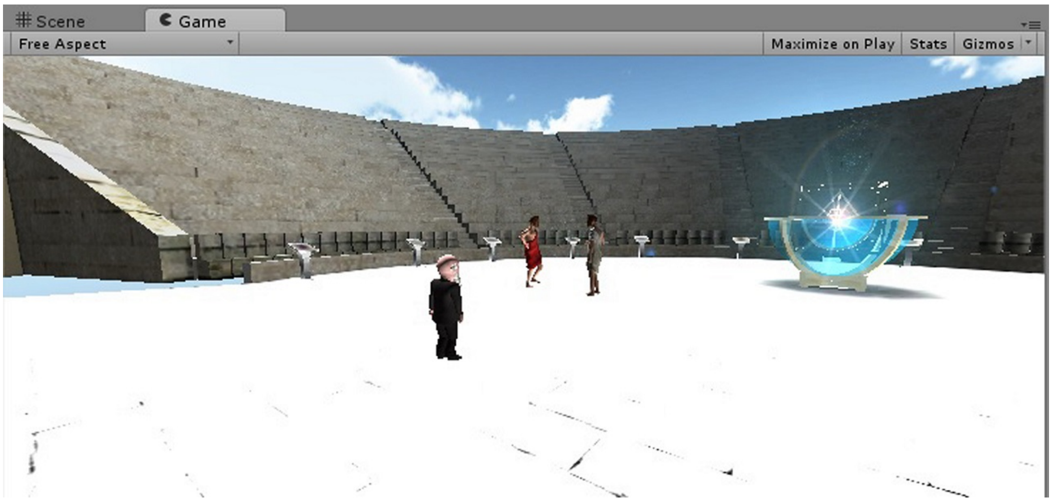


Fig. 6.26 Histoy land where the Ancient Theater is located. View 1

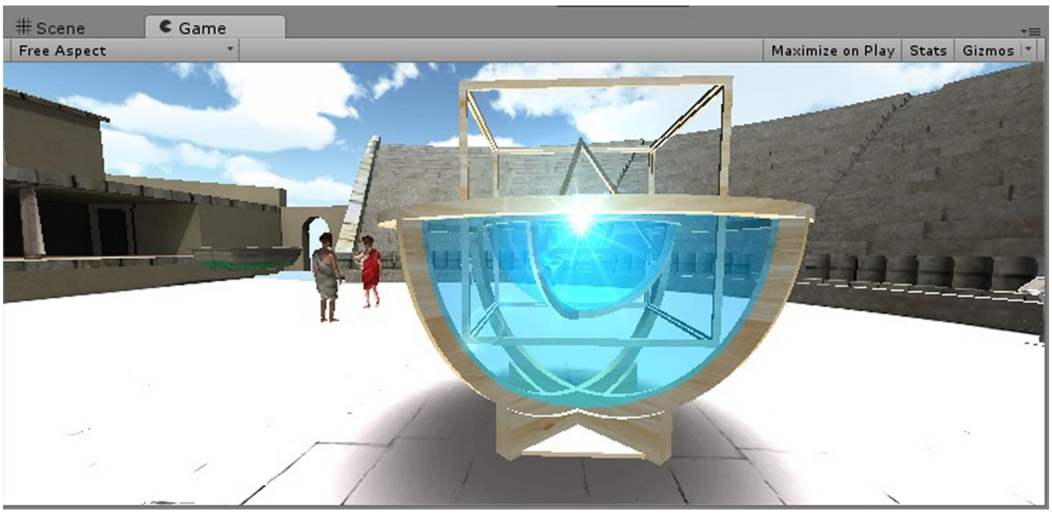


Fig. 6.27 Histoy land where the Ancient Theater is located. View 2

6.7.5 Fifth Scenario: Roman Castle Island

Darwin arrives to a Roman Castle developed also for the ESG at the University of Calabria, here he finds musical objects at the time that he explores the building. The history and art are located in the same place.

See Figs. 6.28, 6.29, and in Appendix C. Figs. C.10, C.11, C.12.

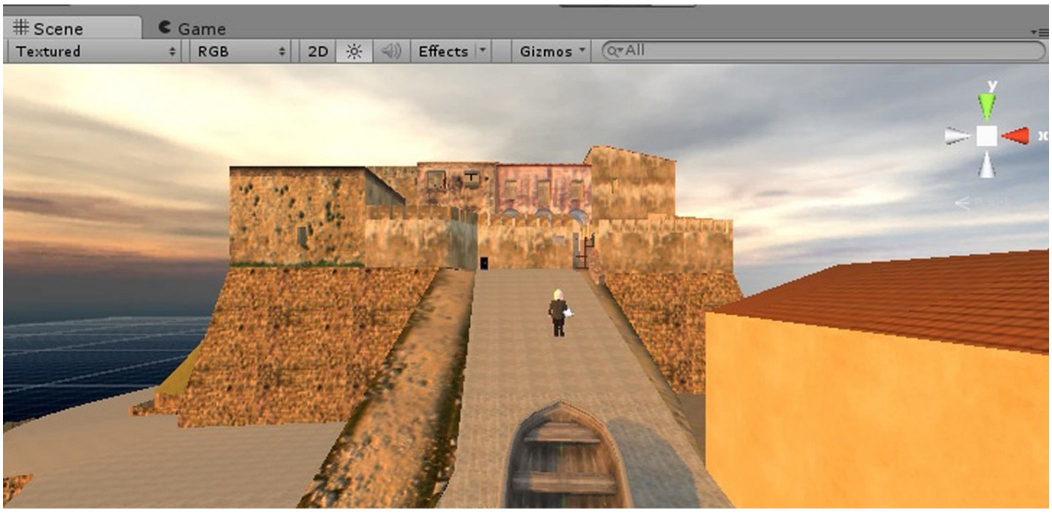


Fig. 6.28 Roman Castle Scenario. View 1

Fig. 6.29 Roman Castle Scenario. View 2

6.7.6 Sixth Scenario: Continental Ecuador

Finally as last option in the menu, the Darwin arrives in a metaphoric way to the continental Ecuador and explores the different regions showed in two scenarios the firs one has similar characteristics whit the Coast and the Amazon regions for the flora and the texture of the terrain, after the tour, Darwin can take de boat and arrive to the Andes region where the mountains are the main characteristic of the place.

See Figs. 6.30, 6.31, and in Appendix C, Figs. C.13, C.14, and C.15.

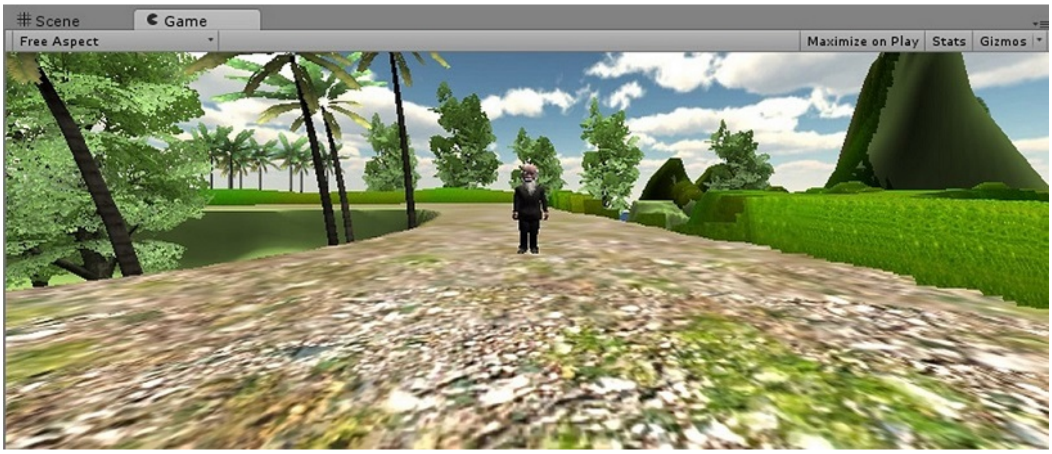


Fig. 6.30 Continental Ecuador Scenario. View1

Fig. 6.31 Continental Ecuador Scenario. Highlands

Chapter 7

Studies carried out and Software developed for the S-GAL Platform

"We need technology in every classroom and in every student and teacher's hand, because it is the pen and paper of our time, and it is the lens through which we experience much of our world."

David Warlick

7.1 Studies carried out

The Smart "Galápagos Islands" Platform, offers as part of this research on Edutainments, ICTs, Digital Economy, IoT, MOOCs and Coding several results, some of them were already published.

In this chapter the results of the research are presented in an organized way as follows:

The analysis of users requirements through:

- A first experimentation with pre-service teachers
- A survey applied to Business faculty in order to validate the ICT abilities and uses in an IoT classroom and,
- The collaboration in the study on regards to Big Data over SmartGrid - A Fog Computing Perspective.

Components of the System:

* The Serious game in Scratch, Darwin's journey to discover biological evolution.
* Creation of the different 3D virtual environments in the Galápagos Islands.
* The design of the Web Platform that was showed in Chapter 6.

7.2 Coding with Scratch: a laboratory for Elementary Pre-service Teachers

Currently, the arising requirement of learning complex scientific contents as well as the necessity to use novel digital resources at schools, have emerged issues on the cognitive, interactive and behavior of the "digital born" generation [42], [43], [37]. Therefore, both the reinvention of educational institutions and an advanced suitable training for teachers is being considered, in order to shift the vision of the stakeholders of education, who perceived the school as a world apart by students [44].

In fact, Universities have begun to take into account the present society requirements, almost everyone uses technology every day and teachers also need to confront this demand.

Regarding training on coding for elementary school teachers, many types of research have confirmed a low level of scientific and technological knowledge [234], and a lack of efficacy in science teaching through technology. [159], [286], [287].

Different programming clubs (Coderdojos) for young people have been realized for introducing the basic concepts of coding, also encouraging creativity, enjoyment, and engagement [199], [200], [286], [287].

The exploration of technology in an informal and innovative atmosphere has led to a world phenomenon called "The Hour of Code" [286], emphasizing in showing coding as a driven force to change the world. Actually, from an educational point of view, digital literacy has started being considered as a key for citizens of the 21st century [182], [123], [47], [48]. Thus, programming has permitted the development of logical skills and abilities related to promote creativity and efficiency on problem solving [1], [269], [135], [32], [33], [284], [285].

In Italy, how it was explained in [286] and [287], the Education Ministry following the success examples around the world has established the general concepts of Computer Science at schools. Fig. 7.1.

In this view, all pre-service teachers, elementary school teachers, and teachers not specialized on Science or Computer Science were practically out of this public instruction plan.

Fig. 7.1 Scratch days aimed to Pre-service Teachers [286]

Thus, a Coderdojo and Scratch days were carried out at the University of Calabria as Fig. 7.1 shows (1st. experimentation).

The laboratory called "Coding with Scratch" was executed twice and was aimed to Pre-service teachers, during the next periods:

Semesters: September 2014 – February 2015 and September 2015 – February 2016.

Most of the results were obtained from the first semester group.

7.2.1 Aims of the setting

- To introduce programming as a powerful tool to Elementary pre-service teachers.
- To make pre-service teachers not only digital users but also digital makers, being able to create their own applications (App or app).
- To let use Scratch as a visual block-based programming language for promoting novel programmers' media manipulation.
- To development the Computational Thinking (CT) Skills, and,
- To improve the Team Work Competency (TWC)

The "Coding with Scratch" laboratory was explained and published in two articles:
* "Coding with Scratch: The design of an educational setting for Elementary pre-service

teachers" [286].
* "An Educational Coding Laboratory for Elementary Pre-service Teachers: A Qualitative Approach" [287].

7.2.2 Subjects

Semester: September 2014 - February 2015

The total group during the first semester were 141 students. Results of the laboratory application were obtained according with the projects presentation.

Thus, for the first study, where the methodology was reported, the sample was composed of 58 pre-service teachers enrolled in a Motor Science course, of Elementary Science Education Master's degree, at University of Calabria (Italy).

For the qualitative research, another team finished the application and the sample at this time consisted of 64 students (M = 13; F = 51) aged between 18 and 40 (M = 26; SD = 5.93). In this population, only one participant was 40 years old, and she was attending her second masters' degree. They never have programmed before.

In a general view, information confirmed that participants were not familiar with technological devices and they have never used Scratch software

Semester: September 2015 - February 2016

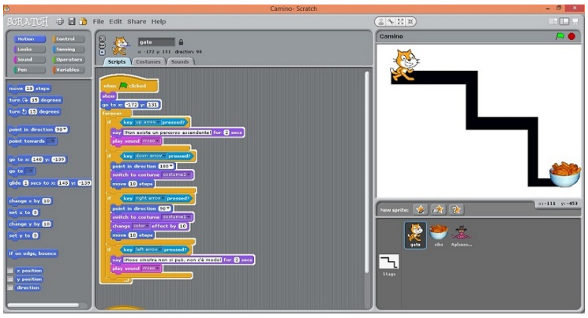
The second group was composed of 178 students (M = 8; F = 170) aged between 21 and 51 (M = 26.67; SD = 6.47). 30 students of this semester have already another degree, that is why exists differences in the population's age.

15.17% of the students in this semester have received some lessons of Computer Science; 10.67% declared that, they know what means a programming language, 6.18% know a programming language but, no one has create an own application. Also they never used Scratch software before.

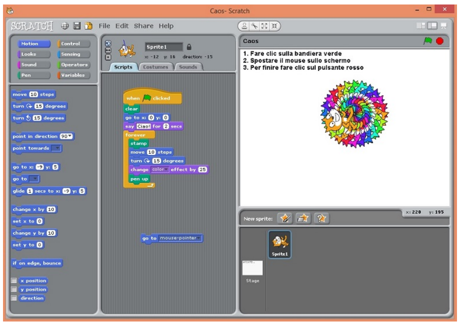
Most of the results on regards to the assessment of applications are still in the collection phase.

Digital Materials

Information regarding programming was carefully prepared and affordable online. It contained in detail, information on the software characteristics, the software installer, Scratch definition, description and applications, the interface of versions 1.4 and 2, etc. and also



(a) Screenshot of a Scratch App



(b) Screenshot of a Scratch App

Fig. 7.2 Examples of coding

programming examples Fig. 7.2. In [286] and [287] the methodology and procedure are better explained.

7.2.3 Procedure and Intervention

The Laboratory "Coding with Scratch" was introduced during the semesters from September 2014 - February 2015, for the first time and after from September 2015 - February 2016.

In the first step, the programming concepts were explained and the Scratch software interface and function. Then, participants formed teams, they chose the application to develop, they defined the users' requirements, and the majority of the time was focused on working on their own projects, in the problem-solving stage. During the whole laboratory, students were able to contact mentors when they required them. Fig. 7.3, shows an example of the team work process.

The implementation of the final project had a subsequent assessment, and feedback to get a better product. Definitely, students applied and learned ICT skills in order to obtain their apps.

All the process was tutored, feedbacks were provided, allowing in this way the revision and testing process before of the final assessment.

Each team had to: 1) take notes regarding the decision-making process, the design and develop of the Scratch application; 2) implement the App; 3) make a report and a user manual and finally if it was possible to test the application.

Teams explained the complete team work process using schemes to summarize it (Fig. 7.4).

Fig. 7.3 Pre-service Teachers using Scratch

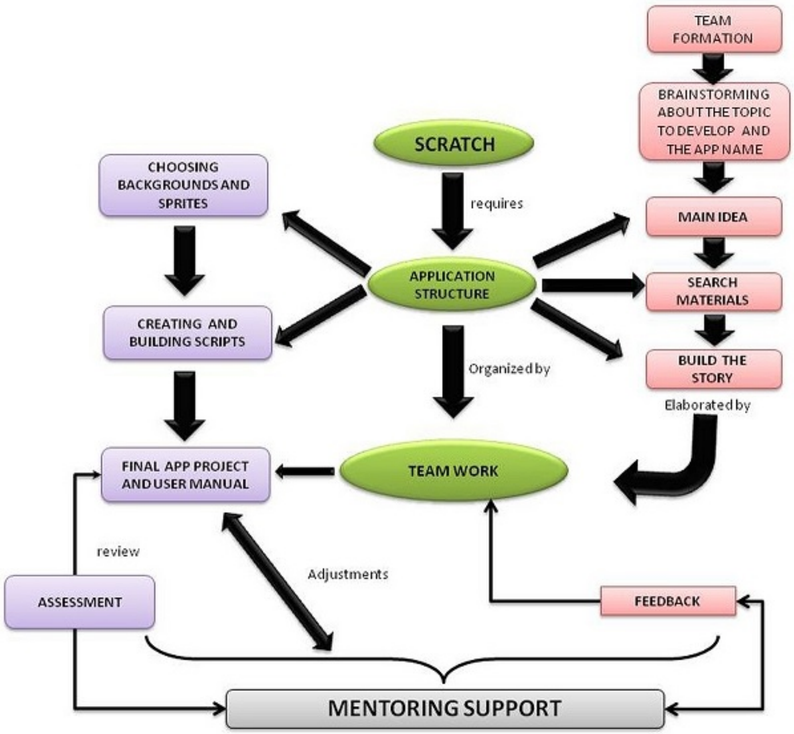


Fig. 7.4 Example of a Team Work process schema

Data Assessment

For a first evaluation, the criteria applied are detailed in 7.1 and described in Vaca Cárdenas et al., 2015 [286].

Table 7.1 Rubric Assessment designed for the authors of this study

	Assessment Aspects
Written Report	Project Process: 1) Problem formulation; 2) Educational Objectives; 3) User requirements; 4) User Manual; 5) Power Point presentation Productively use the time allotted for the project. It ends in the stipulated deadline Collaboration with peers
APP Graphic Interface	App Graphic Interface according to: 1) Target age, Educational Objectives and Skills to development; 2) The App is organized, it has various levels and designs. 3) he graphical interface is clear, it has structure and is adapted both content and program design. 4) It is easy to interact with the program
APP Programming and Function	Computational Thinkings Skills 1) Data collection, data analysis; 2) Data Representation; 3) Blocks understandig function; 4) Use of programming concepts. 5) Sw function/properly debugger program.

Without forgetting that during the rest of the software life, changes, corrections and more goes on evidently forever.

7.2.4 Results

a) Qualitative opinions about the experience

Some of the textual expression of pre-service teacher are summarized in the publication [287]. As a brief summary is possible to say:

Semester: September 2014 - February 2015
Pre-service teachers expressed their thoughts in regards to the "Coding with Scratch" laboratory. Results were absolutely in favor of the experience. They considered it as good and excellent (91.67 %) and as a very strong motivation for developing their creativity (83.33 %).

In addition, students reported that the independence to make their own scripts according to with their own applications was very agreeable. Participants agreed that most of them worked in a collaborative way (79.17%). All in all, the first experience with "Scratch" was considered successful by (81.82%) of participants. See also section 7.4

Semester: September 2015 - February 2016

During the second application of the setting, students considered the experience with Scratch as good and excellent (86.8%) and 100% of participants agree that this, developed their creativity.

Most of the teams worked in collaborative form (80%). For this population, the experience with "Scratch" was considered successful by the (90.06%).

Negative comments also were showed especially at the beginning, an initial lack of predisposition was highlighted, and a constant concern about their self-efficacy as future mentors who had to use ICT in a classroom. Some phrases are described in Vaca Cárdenas et al., and similar results were obtained for other researchers as it is reported [287].

This setting with pre-service teachers permitted to broke negative beliefs that express that people who are not digital natives have difficulties with technology. Scratch was enjoyable and considered as a useful software for Edutainments' development.

Mentor's role was very important to encourage the process in the project development phase. [287], [285], [284], [31], [1], [135], [50].

Quantitative results of the last semester shown that 93.3% of the teams received help during the whole process and also declared that most of them more than ones, arriving at six times in extra hours at the mentor's office.

b) Italian situation

In Italy, even though, the technological age arrived, ICT tools are not available at schools, the use of ICT is rare especially in elementary education. In one hand, the investment in technology at schools is low and on the other hand, teachers reject educational technologies due to they have not studied them or they have not received any trained. At an international level, many programs are in process with great outcomes, U.S.A is an example of it [287].

In this research, preliminary data show that laboratory modules, arranged during University courses, could promote pre-service teachers' familiarization with the most used technologies at school. Following this approach, teachers could perceive themselves as effective mentors, and use technological devices in the classroom.

7.3 Computational Thinking skills: a survey with Italian students

In contemporary society, digital literacy has become one of the basic competencies to foster the acquisition of students' Computational Thinking (CT) skills [309]. The definition of these skills [145] is still ongoing, and their attainment has mainly been based on programming [177], [272], the Do It Yourself approach [152], [77], digital fabrication [76] and educational robotics [134], [135].

Furthermore, in many countries, a CT empowerment in educational practice for both students and teachers has been carried out [17]. Programming has been promoted for encouraging digital consumers to become "prosumers" (the term is the mixture of "producers" and "consumers") [39], [41].

In this view, thanks to its three core design principles "make it more tinkerable, more meaningful, and more social" than other coding languages; [249], Scratch software [16] has started to be used as a powerful visual programming language for all kinds of users [139], [184].

Pre-service teachers' University training plays a key role in providing a satisfactory level of programming knowledge to digital illiterates [116] , [205].

Courses and laboratories should be arranged to foster CT skills and quantitatively measure learning results.

This laboratory has foreseen the future teachers' design and implementation of educational applications (Apps) related to elementary school topics, as well as their assessment through Denner's criteria [105] (Denner et al., 2012) and a specific software that permits to analyzing the competence level of novice programmers in relation with their Scratch projects developed [218] (Moreno et al., 2015).

Previous Research

Numerous research works confirm that training and the educational activities based on Scratch "coding" can allow a fruitful production of digital content [308]. The coding activity holds students in activities related to different levels of complexity, and the Apps production foresees not only a users' general digital literacy, but also the acquisition of CT skills (as the definition of a problem, its reformulation breaking it into smaller solvable parts, and the identification of the steps for solution). Moreover, Scratch promote a friendly opportunity to coding due to the "remixing" approach. This characteristic refers to the possibility to use a project already available on the Community, edit it, modify a part of the code, combining source materials, giving credit to the creator of the original project [216].

Denner and the MIT have widely research in this field, working with teenagers and expert mentors on coding, in after school and middle school programs, at this time, the challenge is to work with pre-service teachers as future mentors in the classrooms [103], [104].

Pre-service teachers and digital literacy in Italian University context

In Italian Universities, the curriculum of pre-service teachers who attend a degree in Elementary Science Education foresees some basic courses in Computer Science. For example, the basic level of the course foresees the learning of word processing, worksheets, data presentation, as well as the modality of surfing the web.

The second level of this course is about Educational Technology, it foresees a theoretical presentation of the major new technologies: knowledge and contextualized use in teaching situations; advantages in the use of technology in relation to the cognitive styles in competences teaching and special didactics; educational project for classes of elementary school and kindergarten with the use of technology.

No laboratories are foreseen. Hence, a gap exists between the courses on digital literacy for pre-service teachers, and the use of Educational Technologies in classroom [150], [10], [140], [81], [274], [245], [26], [273].

So that, the Italian Ministry of Education published the circular N°002937 (23/09/2014) on the importance of Computer Science at school, and also the project “Programma il Futuro” [215] was launched.

In this initiatives, pre-service teachers were not considered. As a consequence, pre-service teachers continued to feel programming as something mysterious and difficult, or frustrating and boring [287], whereas several type of research affirm that pre-service teachers' technology-rich practices can be very beneficial for the use of technology at school [157], [96], [190].

7.3.1 Method

a) Purpose of the study

This research was aimed at the investigation of the CT skills gained by 141 pre-service teachers, who were novice programmers, after a laboratory of "Coding with Scratch".

Scratch projects were assessed according to different methodologies: 1) an analysis through Denner's criteria (2012) [105] (Table. 7.5) for detecting the learned programming concepts, 2) the use of Dr. Scratch Software [218], (Moreno et al., 2015) for individuating the competence level of CT skills, and 3) an examination of the report.

Table 7.2 Participants' school background

High School Student (Italian secondary school)	N° of subjects	% of subjects
High School Diploma in classical studies	77	55 %
High School Diploma in scientific studies	10	7 %
High School Diploma in (Foreign) languages	10	7 %
High School Diploma in Pedagogical studies	44	31 %

In particular, research questions on CT skills were the following: what are the programming concepts that pre-service teachers gain in developing an App? What is their CT level after the development of a Scratch App? How is the practical importance of this investigation? What do the findings mean from a practical standpoint in an educational setting for pre-service teachers?

b) Participants

The sample consisted of 141 pre-service teachers (F=128; M= 13) aged between 18 and 40 years old (M=26; SD=5.93), attending a Scratch laboratory in the curriculum of Elementary Science Education Masters' degree, at the University of Calabria (Italy).

An initial demographic survey collecting information on age, sex, schooling, computer science background, and level of familiarity with technologies, showed that a very high percentage of participants had a humanistic high school background (see Table 7.2), that do not foresee a compulsory use of technology. As a consequence, the majority of subjects (93%) had a very low level of digital literacy.

For carrying on the assignment, participants were divided into 40 groups (5 groups = two subjects; 13 = three subjects; 18 = four subjects; 4 = five subjects).

Procedure

This study had a duration of 10 months and foresaw four steps. In the first step, the setting for the experimentation was set up (selection of the location and authorizations), and materials for lessons were arranged (power point presentations, introductory videos to the software, booklets, ad-hoc built apps as examples). This step had a duration of four months.

In the second step, a pilot research on the use of the system by a small number of subjects was carried out in order to adjust materials and collect/analyze qualitative results to improve the experimentation. This step had a duration of three months.

In the third step, an eight weeks laboratory on Scratch 1.4 was carried on. First subjects had to follow theoretical lessons on programming with the selected software (four face to face lessons, two-hours each). Then, they had to design and code an educational app. A detailed description of the planned timetable is present in Table 7.3 . This step had a duration of two months.

In the fourth step, data were analyzed (one month).

In particular, regarding the third step, the eight weeks laboratory had three phases: the decision-making, the implementation, and the follow-up one (See Table. 7.4).

7.3.2 Assessment

First of all, some key information were collected, as the main topics of the implemented App, and the targeted age of the final user chosen by participants. Afterward, two kinds of data were analyzed: 1) the Apps source files; 2) the Report.

Regarding the Report, the presence of the following characteristics were assessed: 1) the problem formulation and the main objectives of the App (Goals); 2) the user requirements consideration; 3) the reporting of the steps to follow in order to run the App correctly in the Guide).

Regarding the Apps source files, they were analyzed according to Denner's criteria (2012) Table 7.5. These criteria define the categories of programming concepts that can be learned using Scratch: Programming concepts; Code organization; Designing for usability (17 subcategories identify the three categories).

With reference to the score, 1 point was attributed to the presence of a subcategory in the project, and 0 to the absence, for a maximum of 17 points.

For individuating the acquired competence level of CT skills, Dr. Scratch demo software [218], [217] , [109] was used. It allows an automatic confirmation of the presence of the following seven parameters:

1. **Abstraction**: helps to break a problem into smaller parts that are easier to understand, to program and to debug.

2. **Parallelism**: is the possibility that numerous things happen simultaneously. Example: two characters execute an action while a character does several things at once.

3. **Logic**: permits to get dynamic projects; so that, they perform differently depending on the situation.

4. **Synchronization**: instructions associated with synchronization allow characters to organize things to happen in the order we want. Example: “wait”.

5. **Flow control** : means instructions related to algorithmic concepts of “flow control” to control the behavior of the characters.

Table 7.3 Planned timetable of the laboratory

	Lesson	Overview of Lesson(s)	Lessons' Materials
Week 1	Lesson 1.- Laboratory activities overview: research aim and Scratch introduction	General overview on Laboratory activities: rules and setting. Scratch introduction: functionalities and application on Scratch 1.4. A guide procedure on how to create an app.	Power point presentations about: Coding introduction. General concepts on Computer Science key concepts. Scratch and its functionalities. Example developed with Scratch. Video: Step by step analysis of an application made with Scratch
Week 2	Lesson 2.- Focus group	Students were given instructions on how to work in a team and how to develop the application A guide procedure on how to create an app.	Booklet with the instructions on how to work.
Week 3	Lesson 3.- Coding	Students were given instructions in how to create a basic App (game, story, etc.). The instructors explain how to make the report and the user's manual to run the App.	Collected data for each app: - Images that can be sprites; - Images for backgrounds; - Texts; - Sounds, etc.
Week 4	Lesson 4.- Work in the specifics Apps	The students worked in groups with the instructor's support.	
Week 5-8	Creating and finishing their own App	Students were able to continue their own App making either by mixing other available applications or by creating a new application by themselves.	

Table 7.4 Procedure Phases

Laboratory phases
1) Decision-making phase A focus group session was carried out in order to: • Identify each team members' role • Define the educational objective • Define the user requirements (children age related to skills) • Design the app functions **2) Implementation phase** **3) Follow-up phase: Report and user manual writing** In the report, each workgroup had to: • List of the roles in the team • Describe the App educational objectives of the app • Report about User requirements • End-users (children) age and possible skills • Outline of the decision tree realized during the work by using a diagram Each group had to assembly a user manual (guide) to explain the App function with images and text in order to allow to other people to run the App correctly and eventually to use the manual in educational context.

6. **User interactivity**: instructions that can help to Scratch projects to be more interactive. For example, the use of the keyboard or mouse to move a character, to answer questions.

7. **Data representation**: Scratch projects need a set of information about characters, to run appropriately. Each character has a number of attributes. In addition, to modify the attributes of the characters, users can use, for example, variables or lists to store information in a Scratch project.

In particular, Dr. Scratch Software assigned automatically 3 levels according to the score gained and the presence of the seven above mentioned parameters. Moreover, it attributed the definition of Basic, Developing and Proficiency (Master) to the projects. Parameters and detailed levels are explained in Table 7.6.

7.3.3 Results

Some key information on the App developed by participants

Forty applications about Elementary School topics, developed by pre-service teachers, were analyzed. The final list of app topics are showed in Table. 7.7.

The target age of the final users varied from three to seven years old. In particular, 13 groups developed an App for final users aged between 3-5 years; 16 groups for a target aged

Table 7.5 Categories and definitions for Scratch's Projects assessment

Categories	and definitions for Scratch's Projects assessment
	PROGRAMMING CONCEPTS
1. Sequence	Are the blocks in a systematic order to execute the program correctly?.
2. User interaction (e.g. Keyboard input)	Using blocks such as ask and wait prompts users to type in an answer.
3. Iteration (Loops)	Using loops forever and repeat to create iterations.
4. Variables	Variables can be created within Scratch and then be used within programs
5. Conditional statements	Using if, forever if and if-else to check for conditions.
6. List (arrays)	Allows for storing and accessing lists of strings and numbers.
7. Coordination and synchronization (Parallelism)	Using blocks such as wait, broadcast and when I receive to coordinate the actions of multiple sprites.
8. Random numbers	Pick Random is used to select random integers within any given range.
9. Boolean logic	Using and, or, not. True or false.
	CODE ORGANIZATION
10. Extraneous blocks	Are there scripts, any blocks that are no initialized when the program is run?.
11. Sprite names (the default is overridden)	Are the sprite names rewrote or are used the default names?.
12. Variables names	Are the variables given meaningful names when setting up?.
	DESINGNING FOR USABILITY
13. Functionality	Does the App run when it starts (when the green flag is clicked)?
14. Sprite customization	Is the sprite used a predefined sprite or has the sprite been customized and to what extent.
15. Stage customization	Is the stage used a predefined stage or has the stage been customized and to what extent.
16. Clear instructions	Has the student defined how the game is supposed to run?
17. App originality	Students create their own App according to the goal?

Table 7.6 Competence level for each CT concepts (source: Moreno et al, 2015) [218]

CT Concept	Null(0)	Competence Level		
		Basic (1p)	Developing (2p)	Profeciency (3p)
Abstraction and problem decomposition	-	More than one script and sprite	Definition of blocks	Use of clones
Parallelism	-	Two scripts on green flag.	Two scripts on key pressed, on sprite clicked on the same sprite	Two scripts on when I receive message, create clone, two scripts with conditionals. Two scripts on when background change to.
Local thinking	-	If	If else	Logic operations
Synchronization	-	Wait	Broadcast, when I receive message, stop all, stop program, stop	Wait until, when background change to, broadcast and wait.
Flow control	-	Sequence of blocks	Repeat, forever	Repeat until
User interactivity	-	Green flag	Key pressed, sprite clicked, ask and wait, mouse blocks	When x is $>y$, video, audio
Data representation	-	Modifiers of sprites properties	Operations on variables	Operations on lists

Table 7.7 Topics of the Scratch's Apps

# of Apps	Topics
4	Recognize and name the colors
4	Counting
2	Counting operation
5	The alphabet (Italian and English)
2	English names of animals
1	Days of the week
1	Seasons and fruits
10	English names
1	Visual attention and reaction speed games
2	Fruits and colors
3	Geography
1	Music
1	Sports
1	Education
1	Emotions
1	Homo sapiens evolution

between 6-7; 7 groups for a target aged between 8-9; and 4 groups developed an App for a final user aged between 10-11 years.

Analyzing the report and the App manual that each team delivered at the end of Laboratory, we individuated that 100 % of the projects clearly identified the problem to solve while the 97.5 % explained the Goal. 100 % of the participants, implemented an App taking into account user requirements, as well as the Data collection (images, sounds, voice records, on so on). At last, 80 % of teams fulfilled a complete user manual, specifying the steps to follow in order to run the App correctly.

CT skills

The implemented forty applications were analyzed according to Denner's criteria (Table. 7.8). As regards the "Programming concepts", 100% of the projects used Sequences, 78% Loops, and 88% User Interaction. The Apps developed by the different teams had different programming complexity.

In particular, Communication and Synchronization commands were used significantly (83%) (they have a critical role when users build more structured and complex projects in Scratch).

Moreover, Boolean operations (13%), Variables (20%), and Random numbers (8%) are concepts that undoubtedly are difficult to learn by oneself. 63% of Apps had Conditional

Table 7.8 Results of CT skills learned by novice programmers

Scratch's Projects Assessment	%
Programming Concepts	
1. Sequence	100
2. User interaction (e.g. Keyboard input)	88
3. Iteration (Loops)	78
4. Variables	20
5. Conditional statements	63
6. List (arrays)	0
7. Coordination and synchronization (Parallelism)	83
8. Random numbers	8
9. Boolean logic	13
Code Organization	
10. Extraneous blocks	5
11. Sprite names (the default is overridden)	25
12. Variables names	20
Designing for Usability	
13. Functionality	97.5
14. Sprite customization	72.5
15. Stage customization	82.5
16. Clear instructions	95
17. App originality	97.5

Table 7.9 Competence level of the scratch projects

Level	% of Projects
Basic	30 %
Developing	60 %
Master	10 %

statements (these blocks are used, for example, when the sprite has to move around and if it touches an object then it causes an event, i.e. the sprites rebound borders or change stages). As regards the "Code Organization", only 5% of the Apps included extraneous blocks, even if the Apps run. In the 25% of the Apps, the default sprite name were changed; 20% of projects included variables, and all of them had meaningful variables names.

As regards the category "Designed for usability", results show that Apps had functionality (97.5%); they were created according to the goal (originality, 97.5%); the sprites (Sprite customization, 72.5%) and the stages (Stage customization, 82.5%) were customized, i.e. programmers did not use predefined sprites or stages. At last, students defined how the game is supposed to run, hence 95% of the App had clear instructions.

Qualification level of Computational Thinking Skills

The same forty applications were analyzed using Dr. Scratch software. Dr. Scratch identifies the degree of the CT concepts present in the project, giving a CT score. The CT score assigned by Dr. Scratch indicates the competence demonstrated by the developer on the seven concepts shown in Table. 7.6. The obtained CT grades may range from 0 - 21 points [109], [218], [217].

Moreover, this software detects some wrong coding practices or possible errors, like missing characters names, repited scripts, scripts never used and the improper initializing of sprites attributes.

According to the points obtained in each category, a comment appears indicating the level, as follows:

Basic: "You're at the beginning of a great adventure . . . Keep it up!"

Developing: "You are doing a great job!... Keep it up!!!"

Master: "Your level is... MASTER! You're the master of the universe!!!"

The 40 apps were classified as follows: 30% of the projects were "Basic", 60% were "Developing" and 10% were "Master" (see Table. 7.9).

According to Dr. Scratch demo software, the 40 projects assessment had the following scores (See Table 7.10):

Table 7.10 Dr. Scratch assessment

CT Concept	%
Flow Control	61.67
Data Representation	37.50
Abstraction	33.33
User Interactivity	60.83
Synchronization	45.83
Parallelism	48.33
Logic	38.33

In particular, the notions of flow control (61.67%) and user interactivity (60.83%) were the most common coding concepts used. It means that the projects have a sequence of instructions according to specific conditions and also foreseen users interaction in any way.

Followed by the parallelism (48.33%), it means several sprites (characters) were activated at the same time. 45.83% of the projects used synchronization; logic concepts (and, or, not), including conditional commands (if, if - else), were used in 38.33% of the projects; followed by data representation (37.50%) and abstraction (33.33%).

7.3.4 Discussion

The forty Scratch projects developed by pre-service teachers were assessed following two different methodologies. While the first one [105] allowed to detect the pre-service teachers' acquired CT concepts (in designing real applications), the second one [218], [217] allowed to finely ascertain their CT level.

Regarding the first research questions about CT concepts acquired, results shown that after the face-to-face lessons, participants discovered and used sequence, user interaction, loops, conditionals, and finally communication and synchronization in different scripts.

In order to classify and analyze the results, if some blocks were correctly used in a project, it means that a programming concept was understood and learned. Then, in findings, the use of variables, boolean logic, and random numbers was less common but some teams learned to use these concepts over time, as result only two teams used them. In the case of arrays, absolute value and square root never appeared in the projects, since these are advanced coding concepts.

One of the main characteristics of the Scratch approach is the projects "remixing", that is the opportunity to use a project already available on the Community, edit it, modify a part of the code, combining source materials, giving credit to the creator of the original project [216].

Only 29% of the projects used backgrounds images from the Scratch default folder, the rest of teams used their own materials (sound, images, audio file, and so on). In some cases, participants had useful help adopting the "remixing" approach to implement their App, downloading and modifying scripts from the sample projects.

Findings showed that Scratch projects were implemented applying the concept of "designed for usability". Students settled the appropriate way in which the App had to run, they personalized the stages and sprites according with the educational goal and user requirements. Moreover, each workgroup tested their own App with the targeted final users. This approach, allowed teams to develop Apps with a high level of usability as result.

The implemented Apps allowed to handle the modularity easily, due to the facility of Scratch. A modular application allow programmers to decompose the whole program in smaller separated pieces of code (scripts), hence programmers can easily manage interdependencies between the parts of the project, and assemble very complex applications in a reliable way. In fact, in one hand, pre-service teachers created, shared, and reused objects and components; they broken into smaller components or modules the main problem and developed the scripts for each sprite independently and asynchronously before they were assembled into a whole as [70] Brennan found.

On the other hand, Dr. Scratch software detected the CT level acquired by participants through the development Apps: the 60% of the projects was categorized as in the developing level, the 30% as basic projects and the 10% of the Apps got the master level.

In fact, 30% of the projects have a Basic competence level (participants used only sequence blocks, for synchronization they have de command wait and for interactivity only the green flag); 60% of projects was labeled as "Developing" (the Apps had a better definition of blocks; conditional as if – else; loops such as repeat and forever and the interactivity was applied using key pressed or sprite clicked and in addition few of them had used variables).

Ten percent of projects obtained a Master competence level, using all the programming concepts explained except lists or arrays (the Apps had audio records, logic operations, and the same code for different sprites). Hence, these teams were able to manage a little more complex scripts, using, more complex interactivity functions than green flag click.

In the second laboratory applied, until the moment all the projects assessed have a master qualification, it means that the results obtained permitted to improve the new application and to take into account the lacks of the previous course.

7.4 Pre-service teachers improving the Team Work Competency (TWC)

Through the coding laboratory carried out, at the end of formal lessons it was possible also to obtaining some useful information on regards to the TWC.

More recent research described the ways in which the social nature of learning serves as essential motivation and support for young people's participation in computational culture, particularly in the context of computing interactions [73]. Fidalgo-Blanco et. al. (2015) [126] asserts that the acquisition of the teamwork competency is currently very important, in order to assure a proper working performance for individuals. The teamwork model recommends that learning is produced more successfully when small groups of people share information and discuss it altogether. Prior studies advise that giving preservice teachers technology-rich practices can be beneficial on their plans to use technology in the school [157], [96].

Purpose of the study

Specifically, to investigate the following research questions in order to evaluate de Team Work Competency

Which was the Team Work Competency applied by participants during coding activities?, How was the experience of using the Scratch software during this laboratory?, Which emotions were experienced by participants during a coding laboratory?, How was qualified by participants the teamwork?, and, What is your satisfaction level on regards to the project developed on Scratch?

Method of data analysis

A survey to collect important information was applied using a Likert type scale. It consist of items that were measured according to the scale applied. In particular, in order to analyze the Team Work Competency, [203], [126] three Team Work categories were individuated:

- **Collaborative**: each member of the team participates in each activity of the process;
- **Cooperative**: each member has a task, after finishing it, the group joins the parts;
- **Leadership**: the leader decides the tasks for the different team members.

7.4.1 Results

As showed in Fig. 7.5, the most used modality is collaborative (82,5%), followed by cooperative (10%) and in the last place we found the leadership (7,5%).

Most of the groups chosen collaborative work modality, it means also a collaborative learning, each member contributes to every single part of the project involving people

Table 7.11 How was the experience of using the Scratch

Frequency	Excellent %	Good %	Fair %	Poor %
How was your experience with Scratch	37.5	54.2	8.3	0,0
In what way has Scratch developed your creativity	45.8	37.5	16.7	0.0
How do you judge this group experience	37.5	25.0	29.2	8.3
How do you evaluate the possibility of working in teams	54.2	16.7	25.0	4.2

Table 7.12 Which emotions were experienced by participant

Frequency	Yes %	No %
Desire to do it	87.5	12.5
Fear	20.8	79.2
Confusion	62.5	37.5
Dissatisfaction	12.5	87.5
Satisfaction	91.7	8.3
Joy	87.5	12.5

working together for a specific purpose. To get the TWC is important, in order to guarantee a correct working performance for individuals. Based on the implementation of the European Higher Education Area (EHEA) [271], the large majority of universities include the TWC in their study programs and, therefore, should do the teamwork assessment to verify if such competency was acquired with evidences. In higher education, the result is fundamentally evaluated based on final work [218].

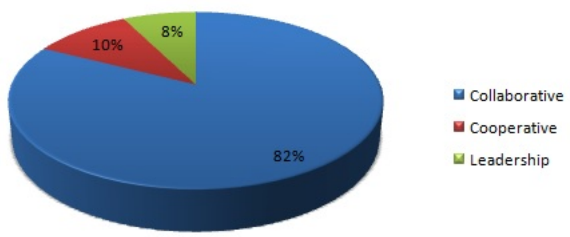


Fig. 7.5 Team Work Competency results

Table 7.11 shows the results to the second research question.

On regards to the third research question, Table 7.12 shows the main emotions experimented during the learning process.

Table 7.13 emphasize the qualification of the teamwork between easy or difficult.

Finally the satisfaction level is detailed in Table 7.14

Table 7.13 How was qualified by participants the teamwork

Frequency	Easy %	Difficult %
How was the teamwork?	79.2	20.8
How was the data collection?	75.0	25.0
Was it helpful for you to have access to the materials?	79.2	20.8
How do you consider the Scratch interface?	75.0	25.0
How was the scripts development activity?	54.2	45.8

Table 7.14 Satisfaction level on regards to the project developed on Scratch

Frequency	%
Very dissatisfied	9
Dissatisfied	0
Neutral	9
Satisfied	41
Very satisfied	41

The assessment of the TWC development was leaded out by student opinion surveys, in order to consider students' perceptions [126]. In particular, pre-service teachers judged their experience with Scratch as excellent and good (91.67%"), able to stimulate their creativity (83.33%), the setting applied had offered them a good possibility to interact with their colleagues improving the TWC (79.17%). During the project development the students have been experienced some emotions as: desire to finish the project, a little confusion, satisfaction and of course joy.

The population on study considered that the teamwork, the collection of materials and the access to them were easy as well as the user interface of Scratch and the scripts construction (coding activity). After all pre-service teachers were satisfied and very satisfied with the setting applied (81.82%).

Finally, some student's thoughts are reported:

"The opportunity of interacting freely among colleagues on a new aspect has stimulated and motivated us to reflect on the disadvantages and advantages of the team work. It has produced in each meeting uniformity of thoughts or divergence of opinions among us, and it was an innovative training experience. To get the final App we proceeded by essay with a countless attempts". "Scratch offered us the opportunity not only to use it but also to create our own App, we were not only users but also digital makers". "In conclusion, programming with scratch was an interesting and fun experience. This software is suitable and useful for learning coding. As future teachers, Scratch will helps us to engage students with technology in our teaching practice, because, it is available to everyone".

7.5 Business Teachers' ICT skills and uses in an IoT classroom

Ubiquitous Internet connectivity and widely accessible ICT devices in the last decade have changed the perspective of higher education community. Many have claimed that technological changes will dramatically alter both business and pedagogical models in higher education [164]. In fact, this trend has continued with the advent of the Internet of Things (IoT) and its place in higher education [18], [283], [310]. Nowadays, Information and Communication Technologies (ICT) have transformed society. In this modern age, information is power; hence, the management of such information is facilitated through the use of ICTs [5] .

The College of Business Administration (CBA) at a major Midwestern university in the USA has invested in the last year in the construction and implementation of a new state-of-the-art building to be used in all aspects of teaching and learning. A primary goal for this building project was to understand current technology uses and migrate this to a new, ICT enhanced environment considering possibilities offered by the IoT paradigm. Purchasing equipment is one small part of this process. Ensuring teachers and ultimately students are positively impacted is a more important and perhaps more complex task.

IoT systems have enormous potential to bring meaningful value to higher education institutions. However, that value will not be realized, without a thoughtful, responsible and compromised implementation [29], [188].

In order to fully utilize this new set of resources with an eye toward IoT, the CBA installed a demo classroom. It was implemented with a Crestron System fully outfitted in order to prepare faculty to teach in the new building. This classroom was a prototype with the same or similar equipment as what the new building was projected to use. All this effort was implemented to promote active learning and transform the teaching and learning space in an orderly and helpful way [291].

Nowadays, teachers face a big challenge with the new students' generation who have great natural experience with technology and communication tools but lack task-oriented understanding [233], [286].

According to many scholars, students are "Digital Natives" or at least have expectations that include the use of new technologies [208]. They prefer to receive information quickly, they enjoy the multi-tasking and non-conventional access to information and they sometimes get bored with lectures. They choose active rather than passive learning; they have wonderful skills on communication technologies to access information, social networking and professional interactions [241]. These same scholars suggest most teachers, are "Digital

Immigrants", aliens in the digital world, although alternate views do exist [250]. When this happens, then a disparity exists between teachers and students. This can become a big challenge in current education practices [287], [291].

7.5.1 Context and setting

Currently, the new phase of the Internet is on its way: a world of networked smart devices connected each other, this approach is well known as the Internet of Things. The IoT links smart objects to the Internet. IoT can enable a data exchange never seen before, and of course bring users information in a secure form [88], [201]. In a future scenario, the use of IoT systems will enhance productivity, create new business models, and generate new revenue streams. Currently, the world is experimenting with and experiencing a very speed technology revolution [29], [121], [212], [259].

The CBA's classroom related technology

The demo CBA classroom included a Crestron System. Its primary use was to transform the classroom into a interactive and collaborative learning environment. It uses the following technology components (https://www.crestron.com):

- A comprehensive control panel that allows easy selection of content and/or devices to display on the projectors (Fig. 7.6).
- Wireless sound system with lapel microphones to be hear throughout the room.
- Capability to show different content on two projectors, i.e. computer on one projector and an electronic whiteboard on the other screen, or computer on one screen and a student's laptop on the other screen.
- Annotation monitors that allow writing on certain content (e.g. Power Point Slides) showing on the projectors (electronic whiteboard).
- Mediasite (sonicfoundry.com) unit to allow lecture capture and web conferencing using different software.
- Wireless IoT integration of smart devices to the projectors (laptops, phones, iPads, etc.).
- A document camera to interact with physical paper sheets or objects in real time.

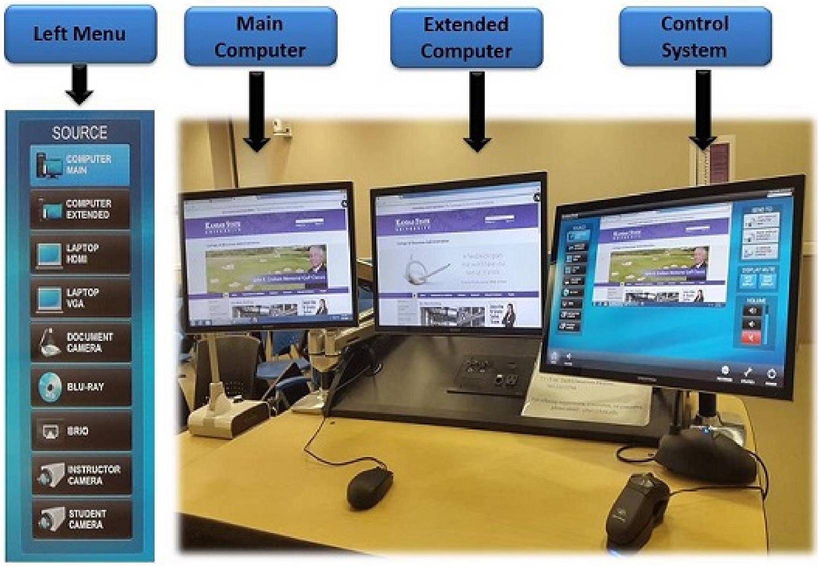


Fig. 7.6 Crestron IoT control system

An online presentation was made to graphically illustrate the new equipment's function. $(http : prezi.comxj7xswg\_zezh?utm\_campaign = share\&utm\_medium = copy\&rc = ex0share)$

7.5.2 Goals

The goals of this study include:

1. Investigate faculty access to and use of ICT devices and applications in an IoT environment;
2. Examine faculty competencies with ICT tools for daily use and for teaching and learning; and,
3. Evaluate the perceptions about using classroom-related technology in teaching in the modern IoT-equipped building of the Business College.

The research questions become:

1. What is the general profile of faculty' experiences and competencies with ICT?
2. What are teachers' competencies regarding ICT in an IoT environment for teaching and learning?

3. What is the faculty perception about usefulness, ease of use, facilitating conditions, and abilities about using the CBA's classroom-related technology in teaching and teaching-related tasks?

7.5.3 Methodology

Participants

The participants in this research were the faculty at the College of Business Administration at a major Midwestern University in the USA. The sample consisted of 32 people (F=34%; M= 66%), aged between 31 and 66 (Average=50.8). The faculty roles included: Instructor (38%), Professor (52%), Administrator (3%), Staff Member (3%) and other (3%).

Instrument

A survey designed and delivered via Qualtrics Platform was applied, (questions were previously tested and validated for reliability) asking about business faculty access, use, and skills with emerging technologies and technological tools; their attitudes towards ICT for teaching and learning; and, the use of the CBA's classroom-related technologies.

The survey was divided into four main sections:

1. Demographic information (including roll, gender, and age)

2. The ownership of a range of ICT devices (desktop, laptop/notebook, netbook, tablet, game console and smartphone). The ICT experience was evaluated by asking participants "if they have the device?".

3. The use and competency of ICT applications/tools which was measured by asking "How many hours do you spend in a week (time range: 0, 1-2, 3-4, 5-6, and more) to use the following applications/tools?" a) for communication/networking; b) media consumption; c) others in general, and d) content creation.

4. This section asked for completion regarding the example classroom set up for training in the following areas: a) Perceived usefulness; b) Facilitating conditions within the university; c) Perceived abilities (self – efficacies) about using the CBA's classroom-related technology; and d) Current CBA's classroom-related technology usage in teaching and teaching-related tasks.

Table 7.15 Ownership of ICT devices

&	Answer	%
1	Desktop	86 %
2	Laptop / notebook	79 %
3	Netbook	3 %
4	Tablet	76 %
5	Game console	24 %
6	Smartphone	83 %

Procedure

Data was collected at the end of the spring semester April and May 2016 when the CBA's example classroom was being used as a training place before the College move to the new modern building. The classroom was set up in order to be used by faculty in their free time for training after scheduled classes and during the semester. The CBA Information Technology (IT) department scheduled times for training processes including teaching circles, and individual time to go in and review the equipment individually. The classroom was available every day from 16:00 – 17:00 and also each Monday from 14:30 - 15:30 p.m. and Thursdays from 10:45 - 11:20 a.m. The survey was sent online. Participation was voluntary and confidential.

7.5.4 Results

Device Ownership and usage of ICT

Starting a decade ago, there was much discussion about the digital, divide between people who was able to afford the digital equipment and others who could not: now the paradigm has shifted. The combination of the mobile computing revolution and the lower costs for ICT devices has modified the scenery. Currently, Mobile computing is a key technology in teaching and learning, and appears to be the path for the future [75].

Table 7.15 shows the results of the access to ICT devices by faculty members. The majority (86%) have desktops, (79%) laptops/notebooks, (3%) netbooks, (76%) tablets, (24%) game consoles and (83%) smartphones. Additional analyses show that the complete sample has access to some type of an ICT device. It is interesting that most faculty members have more than four devices.

Table 7.16 Communication / networking tools

Question	% have used it	Mean	SD	Variance	% of 0	Time 1-2	/hours 3-4	5-6	more
Send & receive mails	100	4.69	0.66	0.44	0.00	0.00	10.34	10.34	79.31
Social networking websites	62.07	2.59	1.59	2.54	37.93	17.24	13.79	10.34	20.69
Participate in message boards	34.48	1.34	0.48	0.23	65.52	34.48	0.00	0.00	0.00

Usage of ICT applications

In general, findings show that teachers incorporate a range of traditional and emerging technologies in their daily lives. The corresponding analysis is represented in a graphical way in Fig. 7.7.

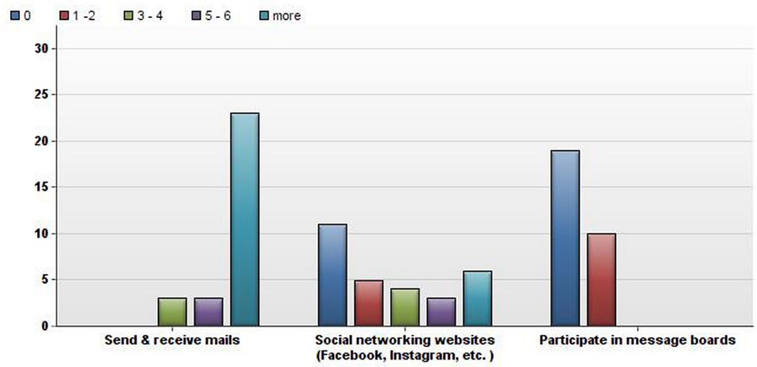


Fig. 7.7 Use of Communication/ Networking tools

As Table 7.16 shows, 100% of faculty use email and 79.31% of them spent more than 6 hours a week sending and receiving emails. These results have an inherent relationship with their teaching activity because the Learning Management System (LMS) “Canvas” that the whole university is required to use in the teaching and learning process during the academic period has email built-in. Twenty percent use emails between 3 to 6 hours a week. Taking into account that the average age of the Faculty is 50, 38% do not use chat or social networking websites, 21% use it more than 6 hours, 17% between 1-2 hours, and 14% between 3-4 hours and 10% use it in the range of 5-6 hours per week. Regarding participation in message boards, 35% use it from 1-2 hours and the rest of participants do not use it.

In regards to media consumption tools, it is possible to see in Table 7.17 and (Fig. 7.8, that 83% of teachers watch videos, 66% spend 1-2 hours watching videos, 3% watch 3-4 hours,

Table 7.17 Media Consumption tools

Question	% have used it	Mean	SD	Variance	% of 0	Time 1-2	/hours 3-4	5-6	more
Watch videos/video casts	82.76	2.25	1.04	1.08	13.79	65.52	3.45	6.90	6.90
Listen to music /audio podcast	51.72	2.14	1.48	2.20	44.83	27.59	6.90	0.00	17.24
Read news /magazines online	93.10	2.96	1.07	1.15	3.45	34.48	31.03	17.24	10.34
Social bookmarking / tagging	37.93	1.46	0.64	0.41	58.62	31.03	6.90	0.00	0.00
Read eBooks	58.62	2.41	1.50	2.25	34.48	24.14	13.79	3.45	17.24

7% watch between 5-6 hours and the same percent watch more than 6 hours a week. 52% of the sample listens to music/audio, 17% listen to more than 6 hours a week. Ninety-three percent of participants read news and magazines online, 17% read between 5-6 hours, 10% read more than 6 hours and the rest fall into the range of 1 - 4 hours of reading per week.

Only 38% use social bookmarking and tagging, 31% use it approximately 1-2 hours per week and the rest (7%) use it 3-4 hours. These results appear to correlate with the social networking website use displayed in results in Table 7.16.

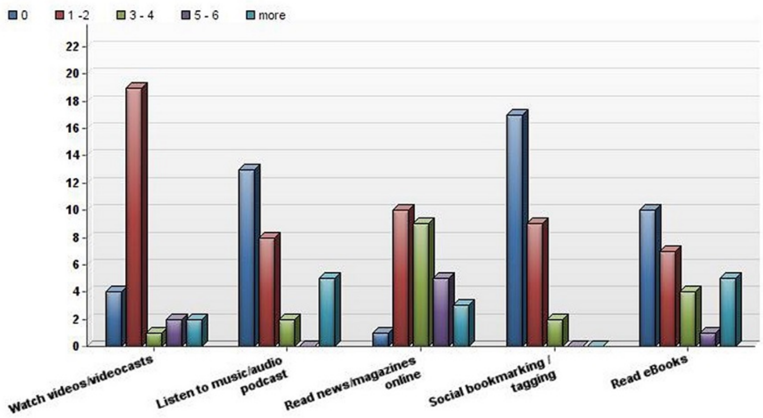


Fig. 7.8 Use of Media Consumption tools

Table 7.18 displays information about general online tool usage. One hundred percent of teachers search for information online, the average being 3.69 hours per week. 30% do it for more than 6 hours per week. Almost 21% of faculty do not use productivity tools and 17% of them use these tools more than 6 hours/week. Only 3% of the population does not shop online and 76% shops online between 1-2 hours/week.

Table 7.18 Others general tools

Question	% have used it	Mean	SD	Variance	% of 0	Time 1-2	/hours 3-4	5-6	more
Search information online	100	3.69	0.93	0.86	0.00	3.45	51.72	17.24	27.59
Use productivity tools	79.31	2.83	1.39	1.93	20.69	24.14	24.14	13.79	17.24
Shop on line	96.55	2.41	1.02	1.04	3.45	75.86	6.90	3.45	10.34
Maintain online photo album	31.03	1.52	0.95	0.90	68.97	17.24	10.34	0.00	3.45
Play online games	31.03	1.55	1.02	1.04	68.97	17.24	6.90	3.45	3.45
Participate in multiusers virtual environments	3.45	1.07	0.37	0.14	96.55	0.00	3.45	0.00	0.00

In the sample, 31% of the participants maintain online photo albums and 69% of them do not use this technology. Three percent spend more than 6 hours updating online photo albums. Sixty-nine percent of the participants do not play games online. Seventeen percent play 1-2 hours per week. Seven percent play between 3 and 4 hours, 3% play for between 5 and 6 hours per week, and 3% play more than 6 hours/week. Ninety-seven percent of the population does not participate in multiuser virtual environments and the rest (3%) do between 3-4 hours/ week.

Competency in using ICT for teaching

Results show that teachers have competences using ICT applications for communication/networking, media consumption and in other areas. However, they do not use emergent applications related to content creation. A majority are even unfamiliar with these technologies.

Table 7.16, Table 7.17, and Table 7.18 results show that teachers perceive themselves comfortable and capable with core technology applications such as email (mean = 4.69), networking (mean = 2.59), watching video (mean = 2.25), listening to music (mean = 2.14), reading online news (mean = 2.96), searching information online (mean = 3.69) and using productivity tools (mean = 2.68). A majority of them use a variety of media tools.

Teachers have the power to transform the way how they deliver education and drive the classroom. They influence many generations of students. This means it is very important they are aware of cutting edge technology and can use it comfortably. Table 7.19 provides

Table 7.19 Content creation

	% have				% of	Time	/hours		
Question	used it	Mean	SD	Variance	0	1-2	3-4	5-6	more
Write blogs/ microblogs	17.24	1.18	0.39	0.15	79,31	17,24	0	0	0
Create graphics	24.14	1.24	0.44	0.19	75,86	24,14	0	0	0
Create or edit wiki	13.79	1.34	0.94	0.88	82,76	10,34	0	3,45	3,45
Design websites	17.24	1.31	0.81	0.65	79,31	17,24	0	0	3,45
Produce videos	17.24	1.41	0.98	0.97	79,31	10,34	3,45	3,45	3,45
Create online mindmaps	0	1	0	0	100	0	0	0	0
Produce audio podcast	10.34	1.14	0.44	0.19	89,66	6,90	3,45	0	0

results about teacher knowledge using other, more advanced ICT applications and tools. See Fig. 7.9.

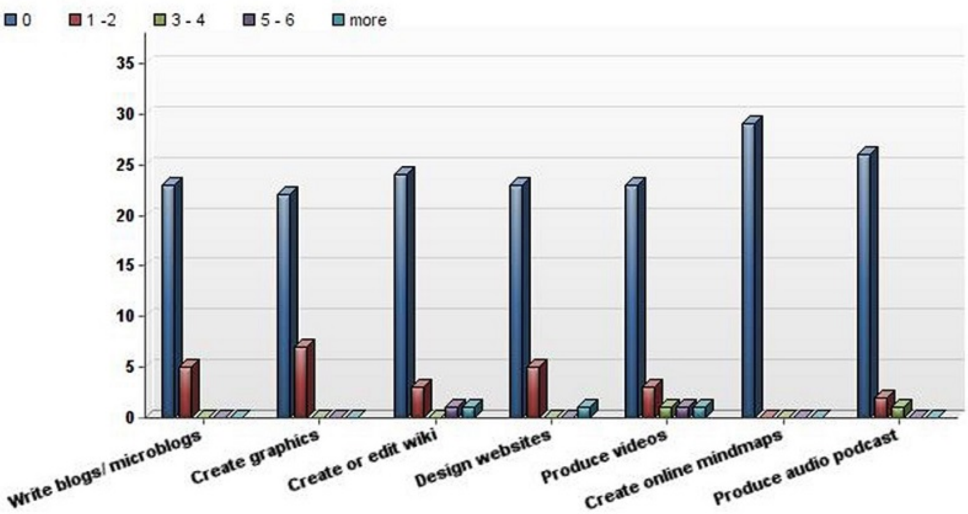


Fig. 7.9 Use of Content Creation tools

The proportion of teachers who had not used a particular application was greater than those who had. From the analysis, the teacher usage outcomes are (those who do not versus those who do): Write blogs (80% vs 17%), Create graphics (76% vs 24%), Create/edit wiki (83% vs 14%), Design websites (79% vs 17%), Produce videos (79% vs 17%), Create online mindmaps (100% vs 0%), and Produce audio podcasts (90% vs 10%).

In general, these results provide a picture of faculty that suggests the basic ICT applications are used regularly but cutting edge tools are not.

Table 7.20 Perceived usefulness about using the CBA's classroom-related technology

				%			
Question	SA	A	SWA	N	SWD	D	SD
Using the CBA's classroom-related technology enables me to accomplish tasks more quickly.	20.69	44,83	20.69	6.90	3.45	3.45	0
Using the CBA's classroom-related technology enhances the quality of my work.	34.48	41.38	10.34	10.34	0	3.45	0
Using the CBA's classroom-related technology makes it easier to do my work.	37.93	34.48	10.34	10.34	0	6.90	0
I find the CBA's classroom-related technology useful in my work.	37.93	37.93	13.79	6.90	0.00	3.45	0

CBA's Classroom-Related Technology - Results

Here a Lickert scale was used to obtain the information, for an easy presentation of the tables, these categories were coded in this way:

Strongly agree (SA), Agree (A), Somewhat agree (SWA), Neither agree or disagree (N), Somewhat disagree (SWD), Disagree (D), and Strongly disagree (SD).

PERCEIVED USEFULNESS about CBA's classroom-related technology

Table 7.20 and Fig. 7.10 indicate that no one strongly disagrees with using the CBA's classroom-related technology, 45% and 21% agree and strongly agree that using the CBA's classroom-related technology enables them to accomplish tasks more quickly.

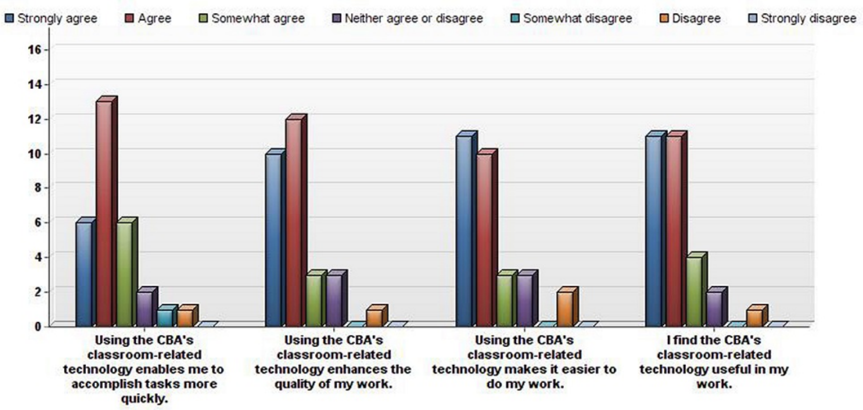


Fig. 7.10 Perceived usefulness about using the CBA's classroom-related technology

Seventy-six percent think that the ICT enhances the quality of their work. Seventy-two percent agree with the statement that ICT makes it easier to do their work, and 76% find the

Table 7.21 Perceived ease use about using the CBA's classroom-related technology

Question	SA	A	SWA	% N	SWD	D	SD
Learning to use the CBA's classroom-related technology is easy for me.	31.03	31.03	20.69	10.34	6.90	0	0
I find it easy to use the CBA's classroom-related technology to do what I want to do.	24.14	34.48	31.03	3.45	0	6.90	0
I find it easy for me to become skillful in using the CBA's classroom-related technology.	31.03	24.14	34,48	3.45	3.45	3.45	0
I find the CBA's classroom-related technology easy to use.	27.59	27.59	31.03	6.90	0	6.90	0

CBA's classroom-related technology useful in their work. Only 3% disagree with various items except for the category related to 'do their work easier'. In this case, the percentage of disagreement is 7.

PERCEIVED EASE OF USE about using the CBA's classroom-related technology

The training plan of the IT department of the CBA according to the data in Table 7.21 and Fig. 7.11 is positive. Approximately 62% (vs. 0%) of the sample agrees that learning to use the CBA's classroom-related technology was easy for them. 59% (vs. 7%) find easy to use it. 55% (vs. 3%) will become skillful in using it. Fifty-five percent (vs. 7%) find the technology classroom easy to use.

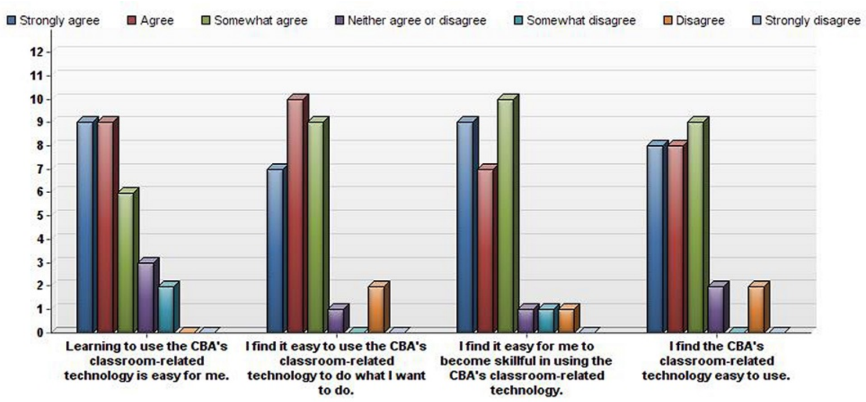


Fig. 7.11 Perceived ease of use about using CBA's classroom-related technology

Table 7.22 Facilitating conditions within the university about using the CBA's classroom-related technology

Question	SA	A	SWA	% N	SWD	D	SD
The resources necessary (e.g. new computer hardware and software. communication network etc.) are available for me to use the CBA's classroom-related technology effectively.	31.03	48.28	10.34	3.45	6.90	0	0
I can access the CBA's classroom-related technology very quickly within my University.	34.48	34.48	17.24	10.34	0	3.45	0
Guidance is available to me to use the CBA's classroom-related technology effectively.	27.59	41.38	24.14	6.90	0	0	0
A specific person (or group) is available for assistance with the CBA's classroom-related technology difficulties.	31.03	41.38	20.69	3.45	3.45	0	0

FACILITATING CONDITIONS within the University about using the CBA's classroom-related technology

Promoting and facilitating access to the CBA's classroom-related technology is a key goal of the IT department.

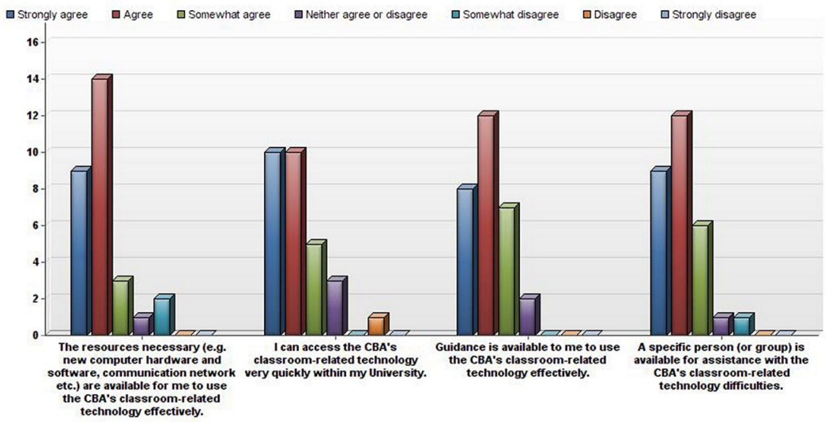


Fig. 7.12 Facilitating conditions within the University about using CBA's demo classroom

Seventy-nine percent agree all the necessary resources: hardware, software, and communication networking are available. Only 7% somewhat disagree. Sixty-nine percent agree and very quickly can access the resources; 3% disagree. Also, 69% agree that support and guidance exist to use the available resources. No one disagrees and 7% are neutral. Seventy-two percent agree that a specific person or group exists for assistance with technology difficulties, and 3% somewhat disagree. See Table 7.22 and Fig. 7.12.

PERCEIVED ABILITIES (SELF-EFFICACIES) about using the CBA's classroom-related technology

Table 7.23 shows that 79% feel comfortable with using the CBA's classroom-related technology by themselves and 7% does not; 76% (vs. 7%) are is able to use it. Sixty-two percent can complete the tasks and know they can call someone for help if they need it. Twenty-eight percent are neutral about it. Fifty-three percent agree with the idea that if they have a lot of time they can complete the planned tasks. Twenty-eight percent are neutral and 3% disagree. In addition, Fig. 7.13 shows a graphic description.

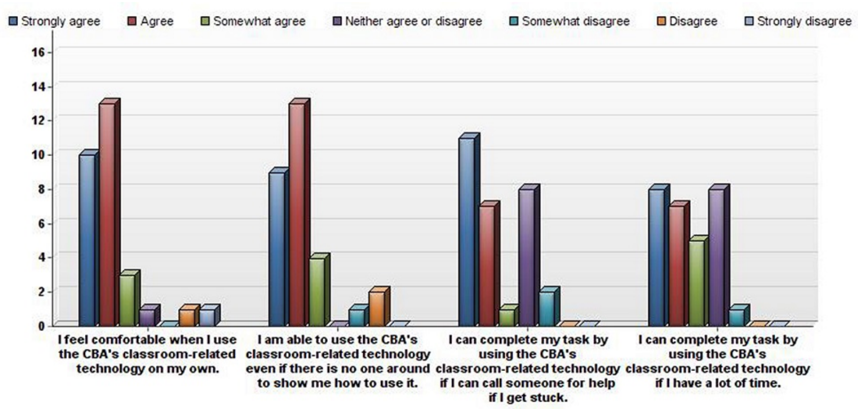


Fig. 7.13 Perceived abilities (self-efficacies) about using CBA's classroom-related technology

CURRENT CBA's demo classroom USAGE in teaching and teaching-related tasks

In Table. 7.24 and Fig. 7.14, 93% express that they use the CBA's classroom-related technology when they are teaching. 3% disagree with that statement. Meanwhile, 83% use it for facilitating teaching; 7% disagree. Moreover, 55% use it for preparing teaching materials; 21% disagree. In addition, 52% use it for enhancing their teaching knowledge. Fourteen percent do not. Sixty-six percent use the CBA's classroom-related technology for student contact and for giving advice; the remaining 17% is neutral in this specific aspect.

Table 7.23 Perceived abilities about using the CBA's classroom-related technology

Question	SA	A	SWA	% N	SWD	D	SD
I feel comfortable when I use the CBA's classroom-related technology on my own.	34.48	44.83	10.34	3.45	0.00	3.45	3.45
I am able to use the CBA's classroom-related technology even if there is no one around to show me how to use it.	31.03	44.83	13.79	0	3.45	6.90	0
I can complete my task by using the CBA's classroom-related technology if I can call someone for help if I get stuck.	37.93	24.14	3.45	27.59	6.90	0	0
I can complete my task by using the CBA's classroom-related technology if I have a lot of time.	27.59	24.14	17.24	27.59	3.45	0	0

Table 7.24 Current CBA's demo classroom usage in teaching and teaching related tasks.

Question	SA	A	SWA	% N	SWD	D	SD
I use the CBA's classroom-related technology when teaching in classes.	58.62	34.48	0	0	3.45	3.45	0
I use the CBA's classroom-related technology for facilitating teaching (e.g. online syllabus. lectures. noted. tutorials. tests. quizzes. and providing grade etc.).	58.62	24.14	3.45	6.90	0	6.90	0
I use the CBA's classroom-related technology for preparing teaching materials.	37.93	17.24	6.90	13.79	3.45	17.24	3.45
I use the CBA's classroom-related technology for enhancing my teaching knowledge.	24.14	27.59	17.24	17.24	0	10.34	3.45
I use the CBA's classroom-related technology for student contact and giving my advice.	31.03	34.48	10.34	17.24	0	3.45	3.45

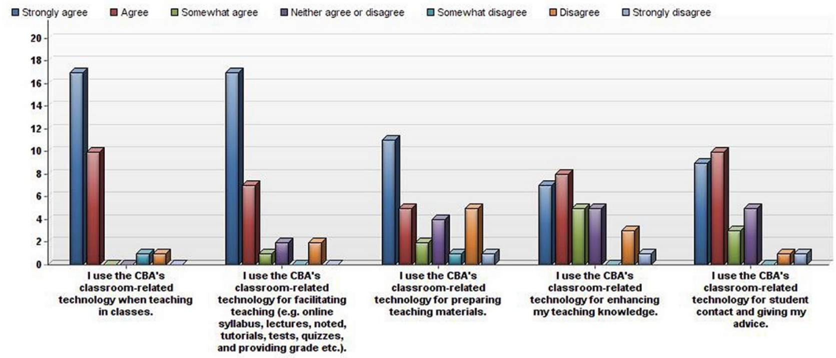


Fig. 7.14 Current CBA's demo classroom usage in teaching and teaching related task

BEHAVIOUR INTENTION to use the CBA's demo classroom in the future in other work

Results in Table 7.25 and Fig. 7.15 have a direct relationship with the attitude and intention of teachers in using the CBA's classroom-related technology. Twenty-one percent disagree with using it more for searching for information for their research.

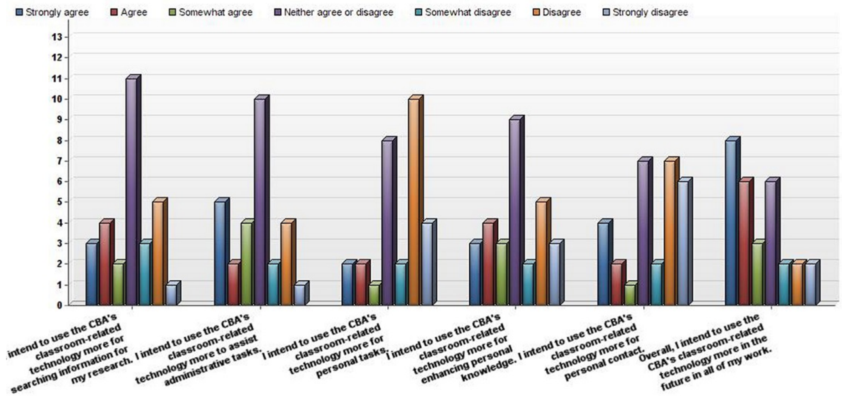


Fig. 7.15 Behavior intention to use the CBS's classroom-related technology

Twenty-four percent agree that it can be used for more purposes and 38% are neutral. Twenty-four percent intend to use it more to assist in administrative tasks. Seventeen percent disagree and 34% are neutral. Fourteen percent intend to use it more for personal tasks.

Twenty-eight percent are neutral, and 48% disagree with teaching resources being used for personal reasons. Twenty-four percent intend to use it more for enhancing personal knowledge; 28% disagree with that use and 31% are neutral. Forty-five percent disagree with using it for personal contact. Twenty-one percent agree with that use and 24% are neutral with this usage. Overall, 48% intend to use ICT more in the future for all of their work; 21% are neutral and 14% disagree.

Table 7.25 Behavior intention to use the CBA's classroom-related technology

Question	SA	A	SWA	% N	SWD	D	SD
I intend to use the CBA's classroom-related technology more for searching information for my research.	10.34	13.79	6.90	37.93	10.34	17.24	3.45
I intend to use the CBA's classroom-related technology more to assist administrative tasks.	17.24	6.90	13.79	34.48	6.90	13.79	3.45
I intend to use the CBA's classroom-related technology more for personal tasks.	6.90	6.90	3.45	27.59	6.90	34.48	13.79
I intend to use the CBA's classroom-related technology more for enhancing personal knowledge.	10.34	13.79	10.34	31.03	6.90	17.24	10.34
I intend to use the CBA's classroom-related technology more for personal contact.	13.79	6.90	3.45	24.14	6.90	24.14	20.69
Overall. I intend to use the CBA's classroom-related technology more in the future in all of my work.	27.59	20.69	10.34	20.69	6.90	6.90	6.90

7.5.5 Discussion

This report provides a glimpse of teachers' ownership of uses and competency with ICT devices and applications in a college of business moving into an IoT environment. Our first goal was to determine faculty access level to technology. Our survey revealed that overall, participants have access to many different ICT devices such as desktops, laptop/notebook computers, tablets, and smartphones. In pursuit of our study's second goal, we found that faculty in the CBA have a medium to high level of usage of the core set of ICT applications for teaching and learning, which can be attributed to the technology emphasis and facilities provided by the administration and the college IT department.

However, when the basic computer devices and the core set of ICT general applications are analyzed, the patterns of access/ownership and the competency level with some other emerging applications show considerable variation. General ICT application skills do not necessarily translate into sophisticated skills with other cutting-edge applications. Participants make more use of ICT for communication purposes like sending and receiving mails, media consumption, information searching, and productivity tools. The move into more sophisticated IoT applications is just beginning.

Lower percentages of participants spend time in content creation activities. The results of this report highlight weaknesses in regards to this very important item. It is clear that a complex mix of technology experiences and skills exists among the participants, which could correlate with age, discipline or other factors related to the characteristics of the faculty members. This is not an insurmountable problem. Since a high level of core ICT competencies exist, there is no reason to doubt that additional skills can be developed in the context of training and administrative encouragement.

The third goal was to determine the behavioral intent of the CBA faculty in areas that extend beyond teaching. Most faculties appeared to realize skills learned in the IoT teaching environment could be helpful in research, administration, personal areas, and communication, but fewer than half indicated an intention to use these tools in those areas. Again, training programs that promote additional uses could prove beneficial.

Teachers know that ICT can enable new forms of teaching and learning but it is necessary to work and develop skills according to educational purposes and pedagogy which makes the use of ICT for teaching and learning more meaningful. It is well known that to transfer from a social or entertainment technology to a learning technology is neither automatic nor guaranteed [85].

7.6 Big Data over SmartGrid - A Fog Computing Perspective

The new paradigm of *Fog Computing* (FC) is being fostered by Cisco. It permits to extend at the edge of the network [63], services and Cloud Computing (CC) because applications can run directly here, where numerous digital devices are linked through the IoT [174]. Thus, it exists a relationship between Cloud and Fog Computing. FC improves Quality-of-Services (QoS) and also supports the emerging Internet of Everything (IoE) [97], [292], [213], [95]. In this way FC is being studied as an better option than CC in order to break the centralized processing and execution of applications in the Cloud but cleverly distributed through *Fog Nodes* (FNs) [221].

Fog is close to end-users, this is the difference with Cloud and it permits to eliminate the data traffic. Adding more FNs if it is necessary to cover more "smart things" supporting heterogeneity [307], [102], [221].

FC will permit BD analytics in real time adding a four axis to the BD dimensions, it is the data collection points [260] or FN to the volume, variety, and velocity already known. Today, many sensors and different digital devices are linked to the Internet. Several of them require processing in real time because of their function of control and protection. More details are in [221].

Hence, the tiers of possible communication are: *Machine to Machine (M2M)*; *People to Machine (P2M)*; *People to People (P2P)*. (In [297] a graphic description is presented.

Linking many devices demand an excessive budget so that the solution could be the introduction of Smart Local Grid (SLG) on Fog Virtualization (FV), placed between devices and the Cloud [131].

The Smart Grid (SG) and Smart Local Grid (SLG) transform electric services in smarter. It will facilitate the cities' conversion into smart cities.

SLG allows the communication between machines without pass by the Cloud, thus SLG on FC plugs to the Cloud all digital machines obtaining a *Fog Computing Platform* (FCP), i.e. a "smart" network able to make self-decisions.

7.6.1 Fog Computing Architecture

Fog Platform

Billions of devices are connected to the Internet and many issues appear such as latency and bandwidth joined also to the enormous traffic. To have more control and security it is necessary to build a secure and strong platform between Cloud and IoT devices. It should offer the Cloud benefits and easy communication, which is *Fog*.

FC enables the Internet of Everything (IoE) and IoT. The Fog was shaped to address applications and services that do not work very well with Cloud paradigm [64]. They include:

- *Edge locations, awareness*, and *low latency*
- *Geographical distribution*
- *Heterogeneity* and *large-scale*

Explained in detail in [297]

In Fig.7.16, *FNs* are the stars located between devices and the Cloud.

7.6.2 Smart Grid and Smart Local Grid

Expressly, FC contemplates common market protocols such as Smart Grid (SG), Smart Local Grid (SLG), Smart City (SC), Smart Home (SH), Smart Transportation (ST), energy, agriculture, healthcare, intelligent buildings, defense, predictive maintenance and of course safety and security.

Fig. 7.16 Fog platform explained in [297]

Smart Grid

Smart Grid (SG) is a blended of communication infrastructure [149] and electrical network. It means a power network with *intelligent* energy load balancing that may run on edge devices[9]. Founded on energy's demand, it finds readiness and low-cost scheduling. FC is foreseen to be a key factor in the design of the forthcoming SG [65]. Users will be able to access to their applications anytime utilizing the Fog platform through a device connected to the network edge [297]. SG permits diverse renewable energy sources[156]. Fog supports, at the lowest level short- time storage and at the highest level, semi-permanent storage [65], [297].

As a promising technology appears Micro-grids to integrate with the main power grid and alternate distributed power generators it means low-voltage electricity system with self-generating facilities [265]. A micro-grid can monitor the power flow independently, due to the oscillation in renewable energy sources [148], [300], [294], [293].

Smart Local Grid

Smart Local Grid (SLG) is a blended of communication infrastructure and micro-grids network. SLG rises over time and supplies a easy integration, information and settling that augprades the efficiency of power micro-grids at local level [124]. SLG affords a next-generation approach to solve a big today's challenges by growing the reliability of electrical micro-grids to meet the rising needs of 21st-century.

The insertion of SLG on FP aims to remove the problems of bandwidth and latency. SLG guarantee communication among devices (see Fig. 7.16). On FP, the cost of customization and service is minimum. SLG permits *M2M* direct connexion and real-time decision without going through the Cloud [223]. Applications running on SLG's platform can solve more complex issues through the interaction between Fog and Cloud [100].

7.6.3 Fog Computing (FC) and Big Data (BD)

FC enables to deliver and unleash the right data at the right time to the right people or device in real time taking advantage of geographical distribution, mobility, and location. FC links sensors to CC resources to allow speed making decisions based on BD flow from the IoE. The dare of centralized data processing is being surpassing thanks to newer Data Virtualization Software and FC technology [297].

To transform raw data from sensors and endpoints to actionable information an IoT software called Fog Data Services (FDS) is used [220]. It reduces the network stress. Thus, scalable IoT solutions are built by FDS with reliable APIs over diversity endpoints and devices [297].

IoT data

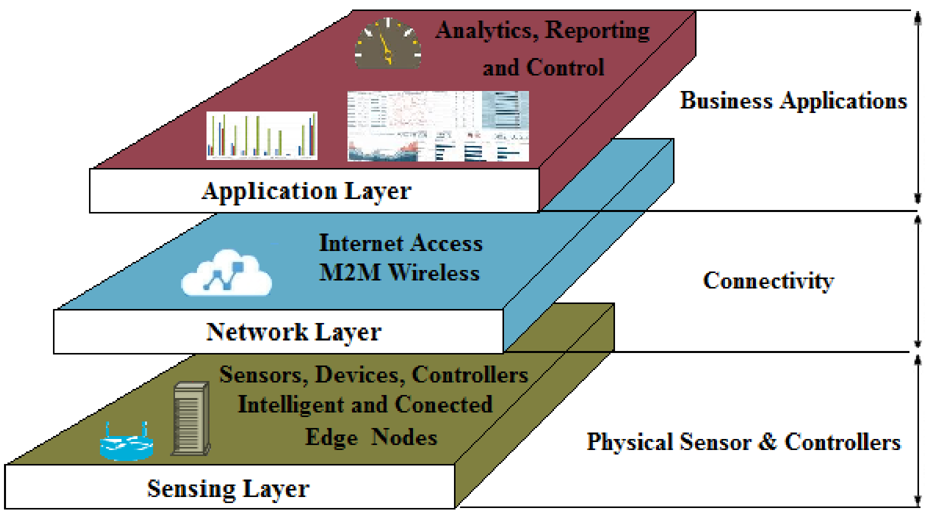


Fig. 7.17 IoT Model presented in [297]

On Fog architecture, IoT is a key factor, IoT is also a significant source of BD especially in smart cities. The network architecture could be organized in three tiers, called, the sensing layer, the network layer, and the application layer (see Fig. 7.17). The sensing layer is liable of data acquisition and consists of different kind of sensors. The network layer is responsible for information's transmission and processing. The interface between IoT services and users is the application layer.

Data flow have these characteristics and are well described in [297]: Large-scale and Heterogeneity

7.6.4 Open Issues

Main aspects such as Education and Transportation, Mobility and Renewable Energy were consider and explained in [297].

Education

The integration of technologies to analyze BD [301] in a system that offers network infrastructure and teaching and learning service across a FCP could be possible, where to get knowledge will be the advantage because each stakeholder of Education generates data that could be transformed into valuable information. Using cutting-edge computing technology [258], [297] .

7.7 Surfing Virtual Environment in the Galápagos Islands

In the age of communication, technology is advancing at an exponential speed and it is becoming progressively powerful and closer to final users [143], [51]. At the same time, each knowledge field has got some benefits from internet, computers, augmented reality and virtual worlds, because users can not only acquire and share knowledge but also collaborate and communicate.

Moreover, thanks to virtual environments, users can feel physically present in a non-physical world [168], [178]. Indeed, every day people hears, sees, and can easily be part of a digitized environment, that enable both the transmission and exchange of information between the user and virtual world [69], [153]. Of course, education can not be out of this constant process of modernization, thus several ad-hoc built learning environments have been ideated and implemented, having some advantages such as flexibility, interactivity and interoperability, also breaking the spatial and temporal barriers [46], [20], [123].

In next section a virtual environment inspired on the "Galápagos Islands" a real and beautiful location in Ecuador, and developed starting from a multidisciplinary point of view comprising Science, Technology, Engineering, Mathematics and Art (STEAM) contents is explained [284], [285].

STEAM education was created to train students with the high-tech skills necessary for the expanding STEAM job market. So that, many investigations are being carried out [187], with the creation of interactive virtual environments, encouraging the study of these disciplines with relevant results on regards to the development of creativity in students of basic education, improving problem-solving skills and motivating children's interest in areas of science and technology, wanting to further explore a "STEAM" career.

7.8 Darwin has come back to the Galápagos Islands: An Educational Journey to Discover Biological Evolution

Nowadays, the great technological changes occurred in the society of information have forced to a revision of the principles, methodologies, tools, and teachers' training in education field [268], [2], [43]. Hence, some Universities have started to exploit the potentials of Information and Communication Technologies (ICTs), offering e-learning opportunities as virtual courses, for instance, in Second Life [66] or online courses followed by millions of students (as the courses offered by the MIT (Massachusetts Institute of Technology)), with virtual teachers interacting around the world [82], [80], [284], [285].

As it was manifested in [284], [285], teachers and students have created strong learning/teaching communities, with a remarkable improvement of educational achievements , [314], [74], both from a cognitive and practical point of view [62]. Moreover, many empirical studies assert that games constitute the principal way by which children and teenagers become acquainted with some subjects as they tend to devote a lot of their time on them [236]. As a consequence, other studies have been focused on users' acceptance of games as a learning tool, showing a positive perception among students regarding their use for learning purposes [42], [67].

Therefore, in science education, serious games have been started to be used [204], [183], providing learners with challenges related to learning tasks, and keeping the player motivated [37]. In particular, this need of activating motivation has been significant for the acquirement and increase of young generation's literacy in science, mainly focusing on the capacity of involving learners' emotional-cognitive side through engaging activities of Edutainments.

In this Edutainment, the learning of specific difficult science topics as the Theory of Chaos is taken into account in a Virtual Museum, a user can access to the 3D virtual museum as an avatar, observe pictures or interact with virtual objects [284], [285].

Concerning the learning of Robotics, currently, artifacts have gained a very important role in school laboratories, because it has been demonstrated that building and programming small robots, as well as the simulation of robotic behavior, allow students to develop advanced cognitive skills in problem-solving and in the acquisition of Computational Thinking Skills. However, the use of the implied learning strategies is very difficult in virtual environments.

In this edutainment, an educational virtual system implemented for the studying of difficult topics in science (Chaos, Robotics, Darwin's theory of evolution) through the metaphor of Darwin's journey to the Galapagos Islands on the ship called Beagle is presented. In fact, the game developed in Scratch recreates the trip around the world, started in Plymouth in 1831, in which Darwin collected the data for his evolution theory. In particular, a new and more advanced imaginary museum of Chaos has been implemented in 3D, and a virtual scenario to learn Robotics has been planned. Moreover, Darwin's theory of evolution can be taught through a serious game, easy to use by students in a classroom.

7.8.1 The Environment

The ESG (Evolutionary Systems Group) has ideated and implemented a system able of working in Windows, Linux, and Mac OS X, and developed thanks to different graphics packages. The frame environment is represented by Galápagos Islands, which have been fully modeled in 3D, Fig.6.18 and Fig. 6.19. Moreover, the virtual system has been developed as multiplatform and easily can be adapted to different platforms according to with the requirements, so it runs on a personal computer with internet or in mobile devices; the app of Darwin's game implemented in Scratch can also run on personal computers, smart boards and online with the Scratch software online.

In particular, the following items are foreseen by the 3D environment in the Galápagos Islands:

- a multiplayer system, in which many users can synchronously play in different scenarios, where the game takes place, using the menu and online;
- teacher can create a forum, where the user online can discuss with other users;
- the game could be installed as part of any Learning Management Systems, where positive behaviors (e.g. contributing to discussion forums, rating and reviewing content, collaborating on projects) are rewarded with points and badges, for example to

overcome some difficulties in different levels of the game. This system which adapts to different LMS;

- a virtual guide (that is Darwin, with different physical features, young in the Scratch game journey or old in the 3D virtual environment).

On regards to the last item, in the main environment, the old Darwin is a virtual guide that explains game rules and best practice, giving instructive feedback. All characters present in the system are the following: (See also Fig. 6.1 in chapter 6) [284], [285].

- **Old Charles Darwin**, the users' guide in the virtual environment; it explains the different scenarios, shows the educational activities, and gives instructions.
- **Young Charles Darwin**, a character of the game; he travels on the ship Beagle around the world in the game made on Scratch about the biological evolution theory. In the game, he is user's avatar.
- **Capitan FitzRoy**, a surrounding character, and it is the Capitan of the Beagle travelling with Darwin.

Fig. 7.18 Old Darwin, Young Darwin, the ship Beagle and Capitan FitzRoy. Scracth game

Scenarios

The 3D "Galápagos Islands" virtual environment has been used as a location for three scenarios (already published) located in Bartolomé island. Each scenario allows users to learn and explore interesting topics related to STEAM, to manipulate contents and to acquire several competences [284], [285].

This environment allows the development of specific skills: comprehension, reflection, analysis, production of scientific evidences, and an high sense of participation in science activities.

Regarding to technical characteristics of software, the 3D environment can run on computers and mobile devices. As it was developed in Unity 3D it can be adapted to different platforms without troubles because of the great characteristics of Unity. The 3D virtual environment was developed with the help of several Computer Graphics packages. The Galápagos Islands have been fully modeled in 3D taking into account the physical characteristics of the real world.

7.8.2 Museum of the Chaos Theory Scenario

This museum is located in Bartolomé Island, a beautiful and important island of the Galápagos. In this museum Fig.7.19, the graphical representations generated through mathematical models, denominated “strange attractors” or Chua’s attractors are shown to visitors as it is explained in [284], [285].

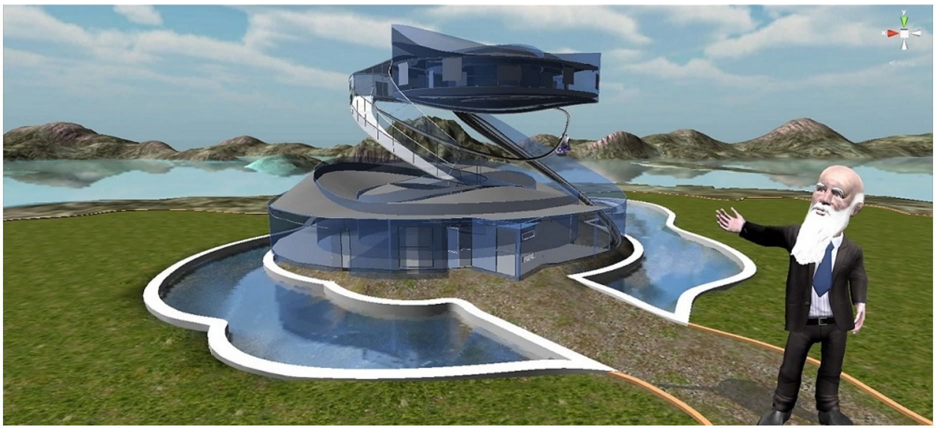
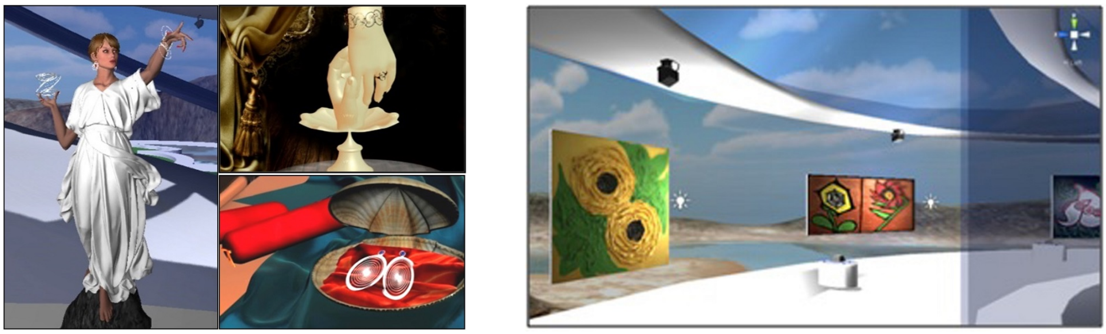


Fig. 7.19 Chaos Museum in Bartolomé Islandy [285]

These models above mentioned offer creative methods related to mechanisms originating from natural evolution, the dynamical systems, evolutionary computation and the strong relationship between them. Due to this, the Evolutionary Systems Group (ESG) at the



(a) Jewerly inside of the Chaos Museum (b) Painting collection in the Chaos Museum

Fig. 7.20 Chaos Museum in [284], [285]

University of Calabria (Italy) had carried out studies related to art and science [38], [52], [53], [56], [55], [35].

The museum allows direct users interaction. User can discover that is possible to match art and science for realizing artistic creations, because of the digital artworks exhibited. Fig.7.20 [284], [285].

Through the virtual tour, users can watch a painting collection, sculpture and jewelry pieces of art inspired in the Chaos theory. Users find several sculptures inspired in the renaissance cultural movement, each one of these statues wear attractor jewels. Fig. 7.20.

In addition, users have the possibility of admiring the outdoor landscape of the Bartolomé Galápagos isle thanks to the crystal walls of the museum. Finally users can participate to the video show “Genesis of Chua” which explains in a illustrated way this theory and the discovering of Chua’s circuit. [35], [40].

In Appendix C, more figures of this scenario are presented C.5, C.6.

7.8.3 Robotics Laboratory scenario

This scenario (Fig.7.21) has been modeled to introduce the user in the wonderful world of the programming. Here the learner can find a virtual tutorial, a forum, and a place where the user can create his/her own programs, rate contents, or collaborates with other users on different projects.

This scenario could be used as a motivation for coding activities, because students can create their own applications in a dynamic and entertaining way. Here different targets can be involved in learning Robotics using Lego or Scratch software. As mobile application, in a simpler version, the system can be used by younger learners and they can also use the Scratch junior software to practice coding [284], [285].

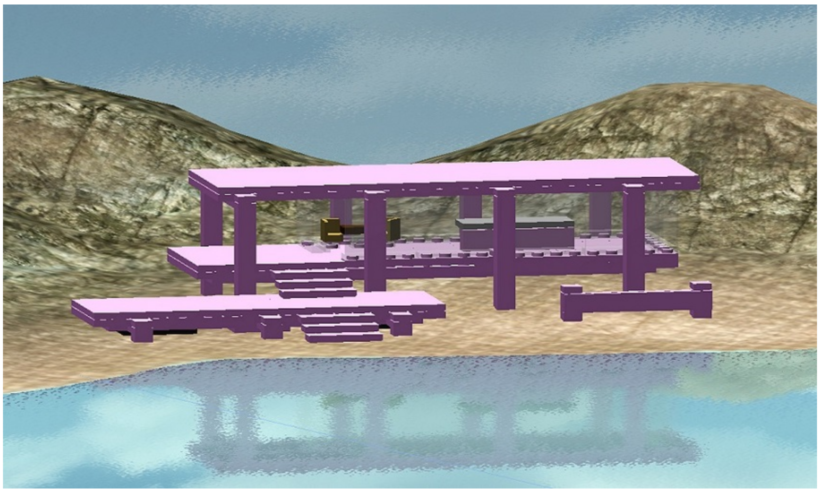


Fig. 7.21 A screenshot of the Robotics Lab. [284], [285].

7.8.4 Charles Darwin Research Station scenario

The real Charles Darwin Research Station is a scientific research institution dedicated to the conservation of biodiversity and natural resources of Galápagos (www.darwinfoundation.org). In the virtual environment, the scenario has been modeled Fig. 7.22 as the real one.

Fig. 7.22 Charles Darwin Research Station modelled. [284], [285].

The building is a trigger to transport users into a virtual tour inside of a remixed museum to watch many of the wonderful an unique species of the Galápagos Islands in 29 pictures on the walls of the station and 12 posters (Fig. 7.23), after of that the user can take the Beagle (boat) to go back at the main menu to the Scratch scenario. In the Scratch scenario the old Darwin can touch anyone of the cubes with the Scratch logo (yellow cat) and activate the

Darwin's game developed in Scratch (see Fig. 6.24). The first screen of the game is showed in Fig.7.18.

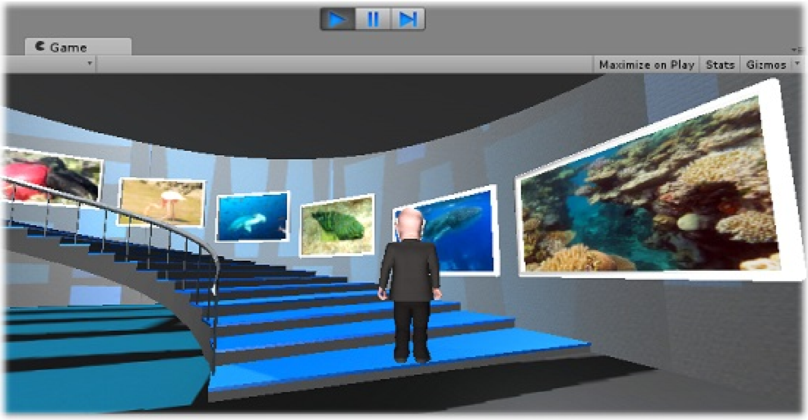


Fig. 7.23 Charles Darwin Research Station

The application allows the virtual travelling from Plymouth (UK) to the Galápagos Islands in Ecuador. Since the final game objective is to learn "The Origin of Species" theory by stages, the presentation is made through four screens showed in Fig.7.24.

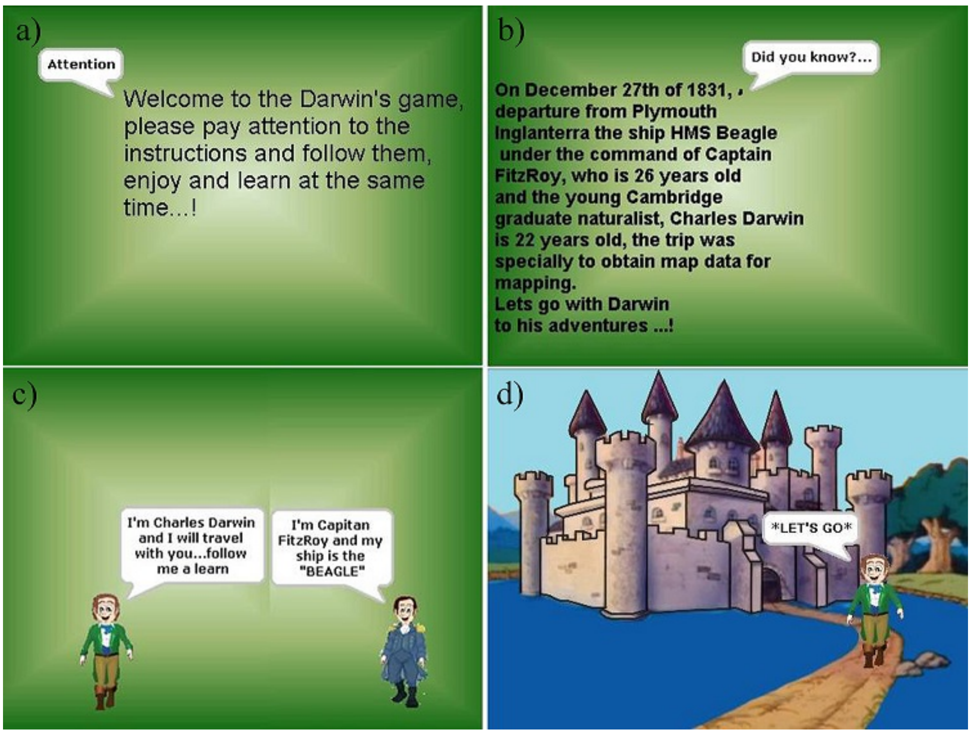


Fig. 7.24 Introductional screens in the Darwin's Scratch game. [284], [285].

The avatar (represented by the old Charles Darwin) is the storyteller in the game, whereas another avatar (represented by the young Darwin) is the user. The young Charles Darwin and the Captain FitzRoy start the game, sailing from Plymouth with the "Beagle" ship.

The player has to surf following the map and the instructions, the map allows the learning of the full tour of Darwin and the implementation of geographical skills. The Beagle navigates and the user has to be oriented in order to move the Beagle through the map to continue the game. There are two maps included in the game. See Fig. 7.25 shows the complete round-trip journey.

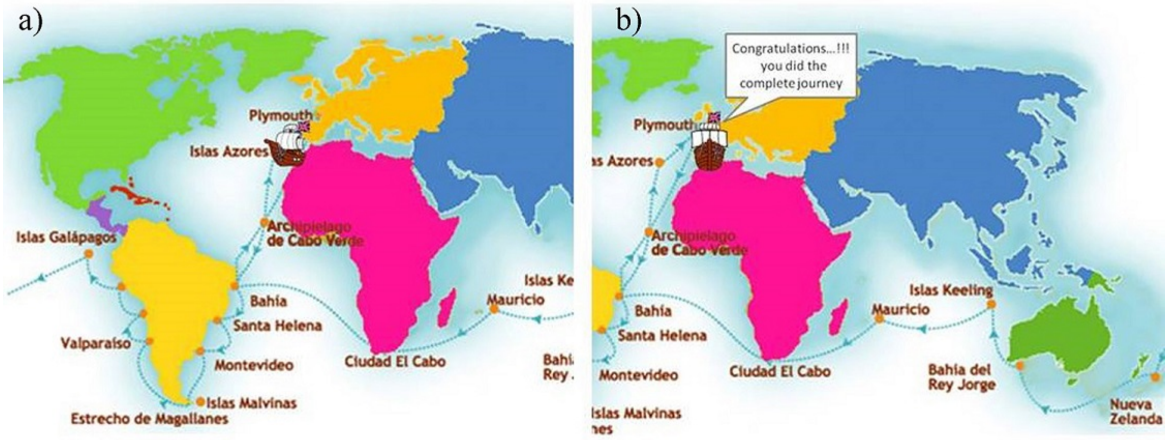


Fig. 7.25 Maps for the Beagle trip in the Darwin's Scratch game. [284], [285].

The game starts in Plymouth England (December 27th, 1831) in a similar way that the real travel that the naturalist did, during this route different scenes are used to explain the adventures and discoveries of Darwin through the origin of the species theory (Fig. 7.26). The user has to collect particular objects important for Darwin's theory formulation; users have to avoid objects that are not necessary because they cause the loss of score.

Continuing the game, Darwin arrives in the multicolored scenario of Brazilian rainforest (Fig. 7.26 a), the player has to collect some species of plants, insects, and other animals as the blowfish that take great attention from the naturalist. Here Darwin's disagreement with slavery has been represented by a particular character (a slave): if this character is touched, the player loses the game.

Going on in the game, another scene is Montevideo, Punta Alta, here user can collect fossilized bones of large mammals, noting also in this visit the difference between savage and civilized man (Fig. 7.26 b).

In another scene, the location is on the Andes (Chile) during an earthquake and also the Osorno volcano eruption occurred. In this location, Darwin receives information about other

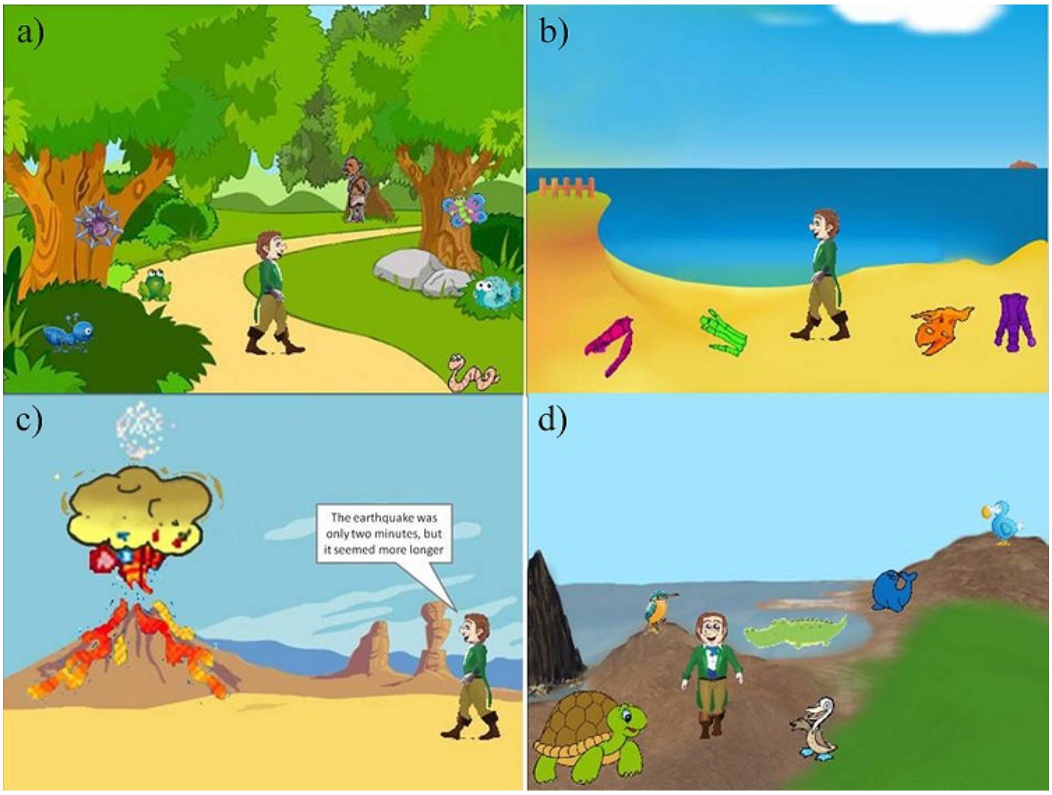


Fig. 7.26 a) Brazilian rainforest, b) Montevideo; c) Volcan Osorno in Chile, and d) Galápagos Islands. [284], [285].

earthquakes so he hypothesizes that could exist an underground communication between volcanoes (Fig. 7.26 c).

Finally, the user arrives at the beautiful Galápagos Islands where Darwin finds many unique species in the world, specific exemplars of flora and fauna as the giant tortoises and the famous finches (Fig.7.26 d).

In each scenario, there are different distracters activities which greatly improve the opportunity of embedding learned contents into long-term memory.

Finally, at the end of the game the treasure appears with all the collected species. Fig. 7.27

In Appendix C, section 7 it is possible to see some screenshots of the Darwin's game code (scripts), the sprites and some customs used in the scenes. Figs. C.21, C.20, C.22, C.23

7.8.5 Qualitative point of view

Virtual 3D systems are widely used in education [44], [1], [83]. Researchers have mentioned that 3D environments have the potential to situate the learner within a meaningful context

Fig. 7.27 The Darwin's treasure at the end of the game

much better than conventional multimedia environments. The quality in the rendering of objects, the behavior of characters within the virtual environment, and the interaction offered in situated tasks are twofold, significative and essentialy motivating for students and teachers also. Frequently 3D environments permit the exploration of places that cannot be visited in an easy way for different factors, such as natural or historical places, outer space or the ocean floor [98]. This is the case of the Galápagos Islands, a Natural Heritage of the Humanity.

3D virtual environment in the Galápagos Islands is a perfect addition for education in any place but, with emphasis in Ecuador due to the above mentioned characteristics and the game approach.

7.9 Special Education: children affected with Autism Spectrum Disorders (ASD)

Special education needs important attention, the ESG [34], [230] at the University of Calabria has carried out different researches for ASD subjects taking into account that a big deficit and a diagnostic criterion for autism is their difficult in the area of social interaction. In fact, persons with autism may have deficiencies in the use of non-verbal behaviours such as body posture and eye contact, it difficulties typical relationships with peers, and their participation in a limited form in common activities such as conversations and games [14], [289], [87], [290], [86].

Many research have demonstrated as individuals affected by an ASD can use and interpret virtual environments successfully, [34]. As in [230] is explained Video modeling as an effective tool for teaching a variety of skills to ASD persons [138], [235], [133], [225], [251], [186], [230].

7.9.1 A Video-Modeling System for improving social skills and lexicon in Autistic Spectrum Disorder children

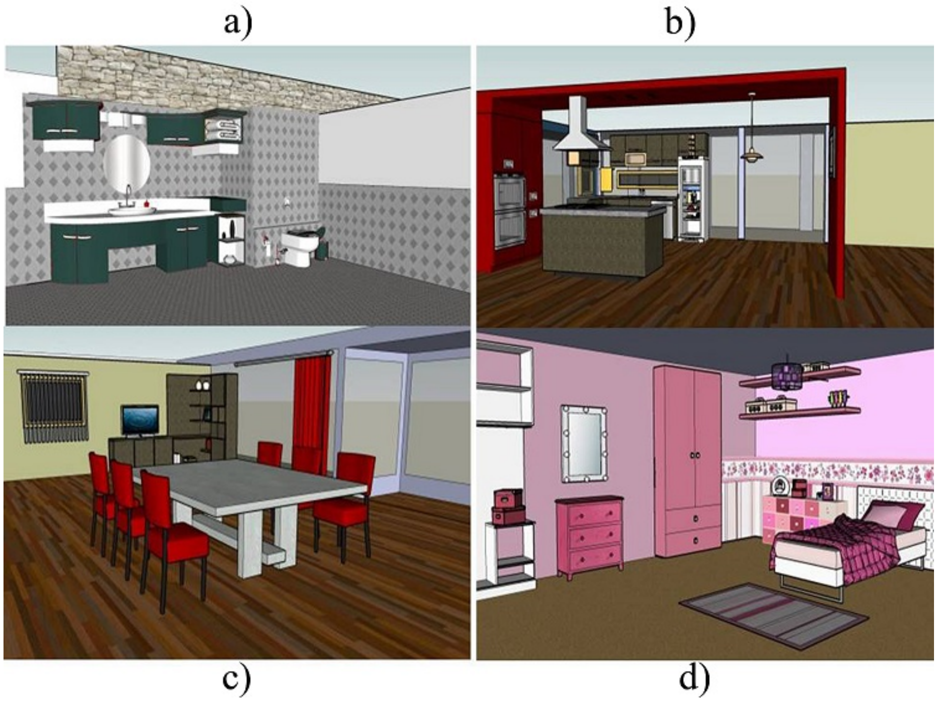
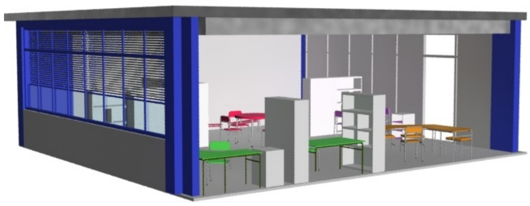


Fig. 7.28
A familiar home scenario. a.- Bathroom; b.- Kitchen; c.- Dinningroom and d.- Bedroom

This system has been developed to help and solve the principal problems of ASD subjects that everybody knows: language delay, the lack of social relationship and the stereotyped movements. The purpose is to teach ASD subjects important skills working in usual environments that they can recognize easily and get into without any problem using ICT, we are sure that the new technologies are very attractive and get the attention of the users quickly.

Two real life scenarios (Home and School) have been designed as video modeling and games, with the possibility to choose a self-tailored avatar of girl or boy (Fig. 7.28, Fig. 7.30).

The video modeling or observational learning refers to the imitation of ASD subjects of other people behavior, thus acquiring a huge repertoire of social skills, with or without the present of a reinforcement action, in this case a reinforcement is presented. Here the

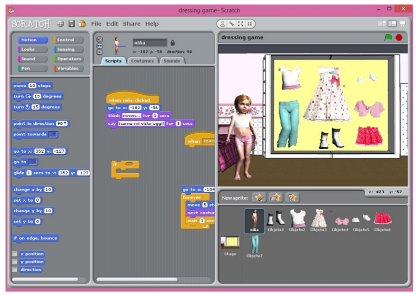


(a) View of the 3D virtual classroom

(b) Children Avatars for the ASD game

Fig. 7.29 Video Modeling System for ASD. [230]

(a) House scenario and dressing activity



(b) Dressing game for ASD children

Fig. 7.30 Dressing Activity. [230]

Take-a-break game model, which foresees a Spaced Learning Activity (SLA) is suggested. This is a learning method underpinned by neuroscientific research, which emphasizes the importance of repetition and short breaks at regular intervals [230].

The basic structure of an SLA comprises: Presentation of key facts of the games; 10-minute break; learner recalls of key facts; 10-minutes break; learner application of key facts. For it, a video modeling and a game in Scratch was developed for teaching and assess the "Dress yourself" activity, see Fig. 7.30a

After the presentation of the different video modeling in each space, the assessment is realized with a game. Here un example of the video modeling Fig. 7.31.

Fig. 7.31 Video modeling example: Take and drink water

Chapter 8

Conclusions and Recommendations

"Knowledge is power. Information is liberating. Education is the premise of progress, in every society, in every family"

Kofi Annan

Conclusions

The "Smart Galápagos Islands" Learning Platform for Digital Economy, Fun, Innovation and Education (S-GAL) was designed based on the studies and experimentations carried out by the ESG at the University of Calabria with input information from pre-service teachers, educators and education experts. The results define and illustrate the skills, knowledge, expertise, and support systems that teachers and students need, to succeed in work, life, and citizenship in this 21st-Century.

The progress of the ICT has changed our way of life, affecting directly many areas of knowledge. In education, ICT has proven to be an exceptional support to both teachers and students [110]. The impact of the ICT, the Internet and the IoT in the society and economy as a whole is so profound that no sector remains unaltered.

In the world, today knowledge and the promotion of the ICT and IoT skills in education is considered as top exigencies to take advantage of the digital age and to improve and guarantee the efficacy of the education system [5]. Therefore, ICT suggests both new approaches for learning and new forms of interaction, changing the relationships in the classroom including peer group, collaborative and cooperative learning [6], [22].

Current society is based on innovation, therefore, creativity and imagination are the principal resources to fostering innovation. This human capital, translated into knowledge is the driver, with knowledge comes power and a way to transform life for the better through newer opportunities according to the Digital Economy.

People with the 21st-century skills will be prepared to face their present and future, thanks to their abilities to make decisions and their capacities of solving-problems in different stages.

Several technics and technologies have been developed by academics in order to acquire, pick, analyze and display Big Data. Thus, the research looks to simplify all these technologies into an overall system that incorporate infrastructure as a service (IaaS), educational data services, learning services with the main objective of share, build and obtain new knowledge through the unique data and information generated for each study [301].

S-GAL is a unified vision for teaching and learning aimed to improve and promote student success in a society where changes are constant and learning never stops.

After this process of continuous research it is possible to arrive to the following conclusions:

Experimentation with Pre-service teachers:

The Coding laboratory for pre-service teachers arranged at the University of Calabria (Italy) to foster the acquisition of Computational Thinking skills, using the visual programming language Scratch had a successful effect on pre-service teachers digital literacy. In fact, our findings showed a full engagement of novice programmers with coding [286], [287]. This was probably also due to the possibility to verify in real time the output of the scripts on the screen. This latter facility is particularly useful for all types of projects. [70], [71].

This Coding experience had twofold advantages: 1) it can be an example that pre-service teachers could apply in their future classrooms; 2) It can be "motivating and friendly" to involve novice programmers in coding activities using Scratch software and the remixing approach. In any case, engaging people in coding not means to turn them into expert programmers, but it means to promote their digital literacy, introducing them in the technological and software world [182]. This remark is very important since almost all students involved in this research had never programmed before of this experience [286], [287].

Regarding on the practical importance of this research it is possible to conclude that in few weeks, students tackled the key elements of coding needed to continue developing Scratch projects with educational perspective and purposes. This two pre-service teachers groups are able to face the 21st century requirements. Pre-service teachers using Scratch gained experience with programming concepts, problem-solving practices by themselves, and widely computational perspectives. In addition, during the learning activities carried out in the laboratory, they were involved in an innovative education process with the use of technological tools, ICT, and, they were able to develop different abilities such as creativity and decision-making. Until the moment, there are very few studies about the Scratch usage at the graduate level and this could be a good example of its use and success [286], [287].

Coding with Scratch laboratory had as spotlight the design of a technology-enhanced setting enriched with digital tools as Scratch. The implemented applications, developed by pre-service teachers, demonstrate not only the opportunity of learning to code without a previous background of programming knowledge but also the prominent interest of pre-service teachers in training experiments in order to face the dare of their future job [286], [287].

The design of a technology-enhanced setting endowed with coding tools as Scratch [286] was judged as potentially engaging and pleasant, even if pre-service teachers' highlighted their concern on the perception of self-efficacy. Pre-service teachers also developed the Team Work Competency and improved their Higher Order Thinking Skills in this challenge of developing educational apps.

Survey applied to Business Teachers

The study carried out to validate the Business Teachers' ICT skills and used in a IoT classroom suggests that the IT department of the CBA of the Kansas State University should provide a teachers training program related to content creation applications. This training can be a great complement to the process already started with the CBA's classroom related technology training and use in order to experience success in advanced ICT in an IoT environment for teaching and learning. Not all teachers possess sophisticated knowledge and understanding of ICT. However, the faculty has a wide variety of information literacy capabilities and latent capabilities.

Teaching competence is a complex blend of intellectual abilities, comprehension, ethical principles, and attitudes, leading to effective actions. Since teaching is much more than only a task, the range and complexity of competencies required for teaching in the 21st century are enormous and the training process according to the requirements is needed. This kind of attention must, therefore, be focused in order to get a great educational system [119].

Survey of Big Data over SmartGrid - A Fog Computing perspective

This study presented an overview of current research in regards to the incorporation of Fog Computing in the forthcoming Smart Grid / Smart Local Grid architectures which support Big Data. Using the BD Smart Grid - Smart Local Grid applications atop Fog

Computing is considered as one of the most suitable techniques to overcome the dares related to conventional management of power grid, in spite the presence of few technical issues concerned to Fog Computing [297].

The three newer paradigms of Smart Grid, Fog Computing, and Big Data were analyzed in this research, including the broad benefits of utilizing BD to design and support Smart Grid / Smart Local Grid applications on Fog Computing Platforms. A list of general requisites for BD Smart Grid / Smart Local Grid applications on FC Platforms were also advised, underlining the importance of these requirements in the design and implementation of efficacious adequate BD applications. Additionally, the technology which is performed to support Fog-based BD SG/SLG systems were cataloged. Finally, some of the main open matters as Education, that should be researched to get a furthermore clear view of SG / SLG were argued [297].

3D virtual environments in Education

The 3D virtual environment in the "Galápagos Islands" as a virtual world lends a massive possibility to change the traditional education, offering the occasion to obtain positive results in learning contexts. The introduced edutainment tool could be used for learning difficult science topics as Chaos “Surfing in the Galápagos Islands” promotes educational paths where theoretical knowledge are strictly linked with creativity to promote innovation and invention at schools [284], [285].

Many studies have confirmed that technology is an impressive method of providing students with special needs high levels of learning through different activities related to their leveles special requirements. The example with ASD subjects and the activity with Pre-service teachers in order to development applications taking into account the student’s needs constitutes by itself a great example of working to an education that solve problems in concordance with the current society. Because, personalized contents can be development if educators or caretakers realize the potential of learning in this case for instance Scratch.

From a global perspective, the 21st-century skills outcomes got by people envolved in this research process after the coding laboratory carried out for two semesters and the study applied with Faculty members of the Business College of the Kansas State University were: Critical thinkers; Problem solvers; Good communicators; Good collaborators; Information and technology literate; Flexible and adaptable; Innovative and creative in their performance activities; Globally competent in a Digital Economy world [17].

Finally, as manifested Tapscott in 2014, “The digital revolution enables cities to better integrate social services, reducing cost and improving value”. Thus, education has the power to transform and promote this kind of society where the most important factor is the human resource, people have to be willing to change.

Recommendations for future work

Coding experience with Pre-service Teachers

From an academic point of view, through the Coding Laboratory, useful information were attained on the arrangement of University courses and specific laboratories, as well as on the possibility of rethinking of the Italian pre-service teachers' curricula. However, results of this study are limited to one group of pre-service teachers, and further studies are necessary with two different groups, an experimental and a control one. In addition, it will be important to have a pre and post-test in order to evaluate the initial conditions and to verify with the post-test how motivation could change the educational paradigm.

The coding laboratory applied can be used for training at different age levels, the methodology and the systematic process underlined in this research are easy to apply in a dynamic educational environment.

Teachers' ICT skills in a IoT environment

This investigation arranged with Business Teachers promotes more in-depth, qualitative investigation of teachers' perspectives on technology. Future work can examine the way in which teacher's competencies in technology are integrated into teaching and learning. By repeating the same study after the move into the new cutting-edge college of business building, follow-up measure can be conducted to determine if new training initiatives and the presence of more ICT resources impact attitudes and overall usage of this important tools for teaching and learning.

IoT in Education

Building the IoT applications has become a global initiative sparking interest in a variety of educational, governmental, and organizational enterprises across the globe. The College of Business Administration initiative is one of these as it outlines the basis to create a smart environment to improve teaching and learning activities while it helps to construct new progressive and accessible channels.

Currently, education and industry are heavily investing in developing IoT systems and infrastructure. Because IoT increasingly seen as a priority in national ICT strategies, new plans to develop advanced computing environments for research, processing, storage and data access to the "Big Data" created by IoT devices is more important than ever for future decision-making [147], [259]. The CBA at Kansas State University has positioned itself to take advantage of these new trends. With further investment in teacher training, these efforts should be successful.

MOOCs and LMSs

Another recommendation is to help advance the knowledge base on MOOCs in education contexts. The majority of the MOOCs reported by researchers are resembled xMOOCs which are similar to the structure of conventional courses performed by higher educational institutions with pre-recorded video lectures by professors, examinations and/or individual final project (submitted online). It is necessary to create motivation to the study of scientific topics in an entertainment way [163], promoting a modern education using new technology through the ICT and IoT paradigms together with the Digital Economy approach.

3D Virtual Environments

The virtual 3D systems are widely used in education [44], [83]. Regarding the edutainment environments developed during this research, experimentations with school subjects have to be carried on, involving different targets of users. Only experimentation results will show if motivation and learning will be implemented, and if corrections to the system are necessary. The general idea is to have this initiative as a pilot project to be implemented in Ecuador in the educational system [284], [285].

Special Education

On regards to users with special needs, examining the benefits of technology use, according to many surveys, it has been defined as an efficient method of teaching, specifically, researchers should test the effects of the use of the software developed on the acquisition of the students' skills.

Currently, teachers have a large number of digital resources and applications to promote novel teaching and learning activities. Today classrooms are becoming 'open' thanks to all those technology infrastructures and collaboration efforts. The principal challenge for the Computer Science area is the development of newer ways of inventive and contemporary education directed to large quantities of students in the world, engaging their several interests, and proposing adjustments in curricula that show the big changes in computing technology.

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Appendix A

Acronyms

Nomenclature	Description
ARPA	Advanced Research Projects Agency after called DARPA
ARPANET	ARPA Network
BBN	Bolt Beranek and Newman corporation
CBA	College of Business Administration
CC	Cloud Computing
CEO	Chief Executive Officer
CERN	European Organization for Nuclear Research
CISCO	Systems American multinational corporation technology company
CLab	Contamination Lab
CT	Computational Thinking Skills
CSNET	Computer Science Network
CSTA	Computer Science Teachers Association
DARPA	Defense Advanced Research Projects Agency
DDoS	Distributed Denial of Service
DiY	Do-it-Yourself
EB	Exabytes
EPC	Electronic Product Code
FC	Fog Computing
FCP	Fog Computing Platform
FCC	Federal Communication Comission
FDS	Fog Data Service
FI	Future Internet
FN	Fog Node

Nomenclature	Description
GB	Gigabytes
GBL	Game-Based Learning
GDP	Gross Domestic Product
GUI	Graphic User Interface
HOTS	Higher Order Thinking Skills
HTML	HyperText Markup Language
HTTP	Hypertext Transfer Protocol
IaaS	Infrastructure as a Service
IANA	Internet Assigned Numbers Authority
ICT	Information and Communication Technology
IGF	Internet Governance Forum
IoE	Internet of Everything
$IoT - GSI$	Global Standards Initiative on Internet of Things
IoT	Internet of Things
ISTE	International Society for Technology in Education
IT	Information Technology
LAN	Local Area Network
M2M	Machine to Machine
MIT	Massachusetts Institute of Technology
MOOCs	Massive Open Online Courses
MOOs	Object-Oriented MUDs
MUDs	Multi-User Domains
NCP	Network Control Protocol
NPL	British National Physical Laboratory
NSF	National Science Foundation
NSFNET	National Science Foundation Network
OECD	Organization for Economic Co-operation and Development
PBL	Project-Based Learning
P2P	People to People
P2M	People to Machine
PHP	Hypertext Preprocessor. It is an HTML-embedded Web scripting policy challenges
R&D	Research and Development
RAND	It is a research organization that develops solutions to public
RFID	Radio Frequency IDentification

Nomenclature	Description
SaaS	Software as a Service
SC	Smart City
SDGs	Sustainable Development Goals
SDLC	System Development Life Cycle
SG	Smart Grid
$S-GAL$	Smart Galápagos Islands
SH	Smart Home
SLG	Smart Local Grid
SMEs	Small and Medium Enterprises
SOA	Service Oriented Architecture
SQL	Structured Query Language
SRI	Stanford Research Institute
STEAM	Science, Technology, Engineering, Arts and Mathematics
STEM	Science, Technology, Engineering, and Mathematics
ST	Smart Transportation
TCP/IP	Transfer Control Protocol Internet Protocol
UCB	University of California Berkeley
UCLA	University of California at Los Angeles
UCSB	University of California at Santa Barbara
UNESCO	United Nations Educational, Scientific and Cultural Organization
VNI	Cisco Visual Networking Index
VR	Virtual Reality
WAN	Wide Area Network
W3C	World Wide Web Consortium
WSN	Wireless Sensor Networks
WSIS	World Summit on the Information Society
WSN	Wireless Sensor Networks
WWW	World Wide Web
ZB	zettabyte

Appendix B

Coding with Scratch

Blocks Categories. Fig. B.1

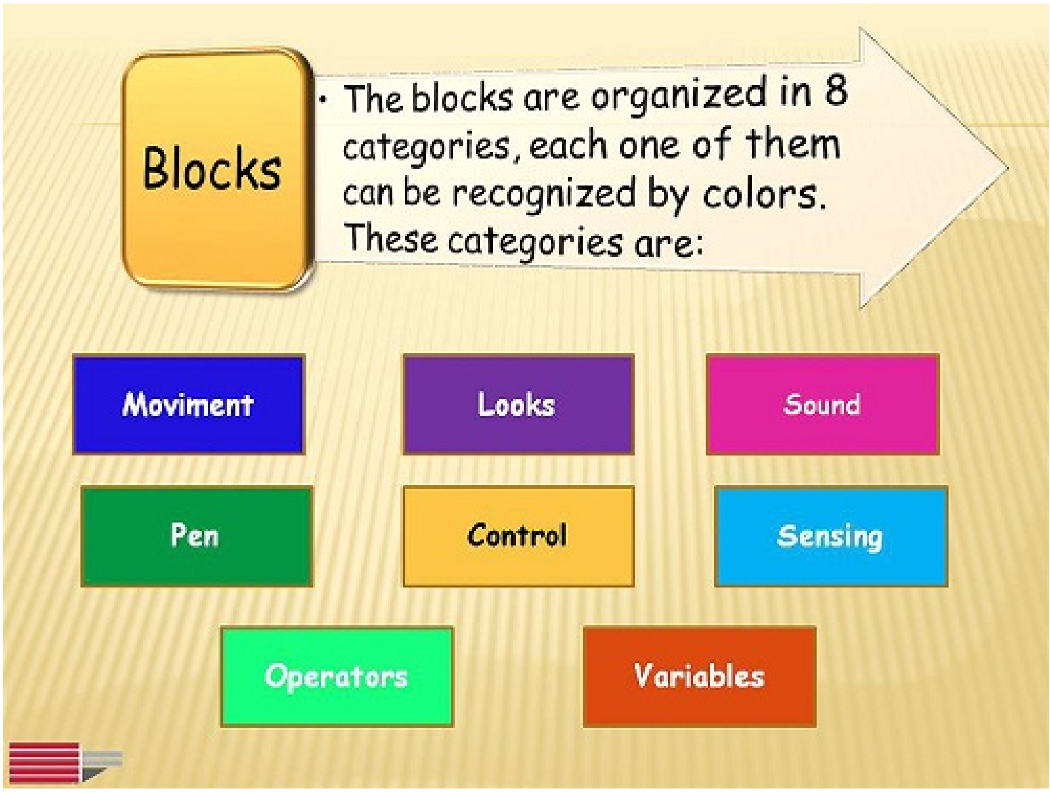

Fig. B.1 Block Categories of Scratch

Next pages show some of the above mentioned categories

Motion. Fig. B.2

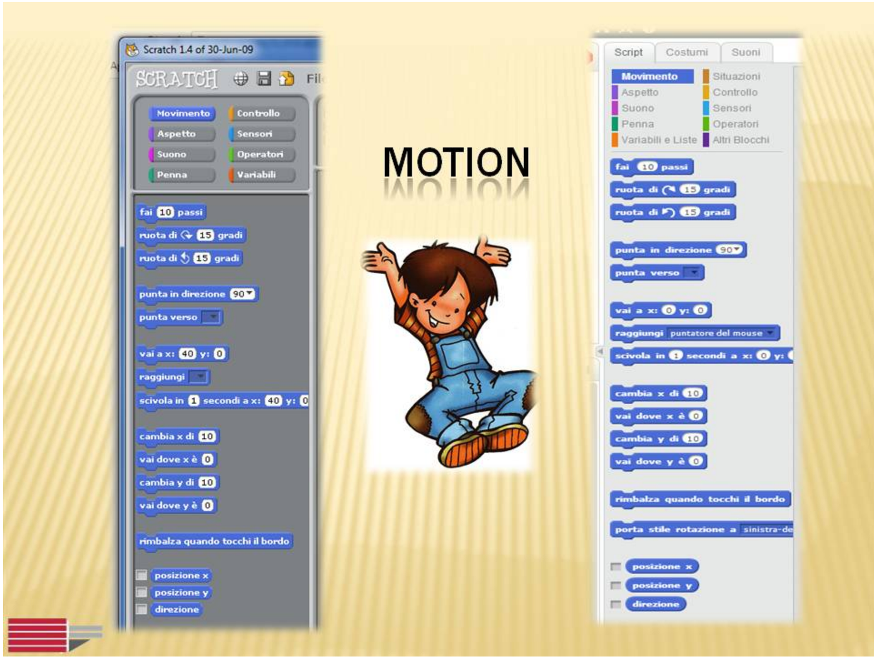

Fig. B.2 Motion Category

Operators. Fig. B.3

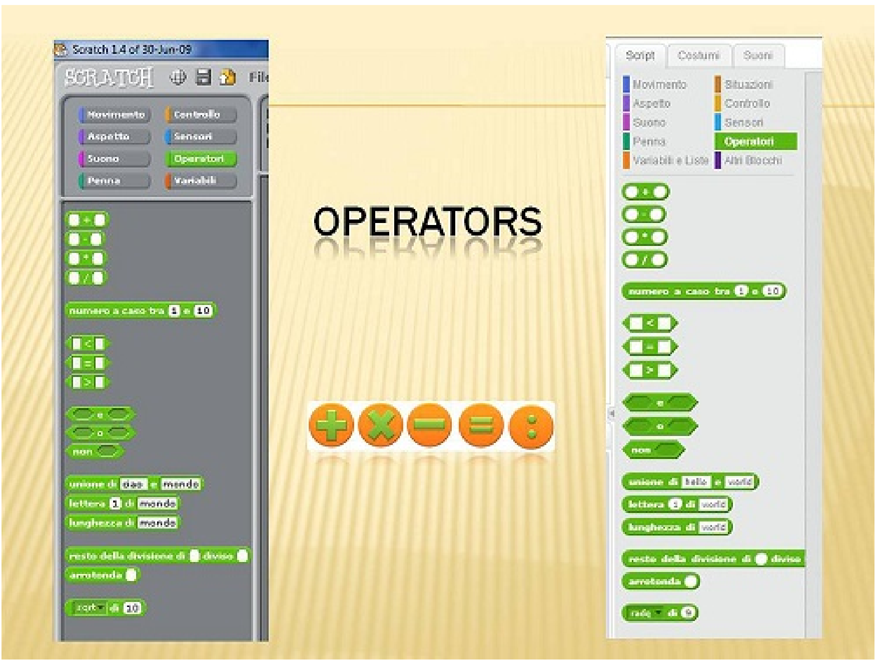

Fig. B.3 Operators Category

Control. Fig. B.4

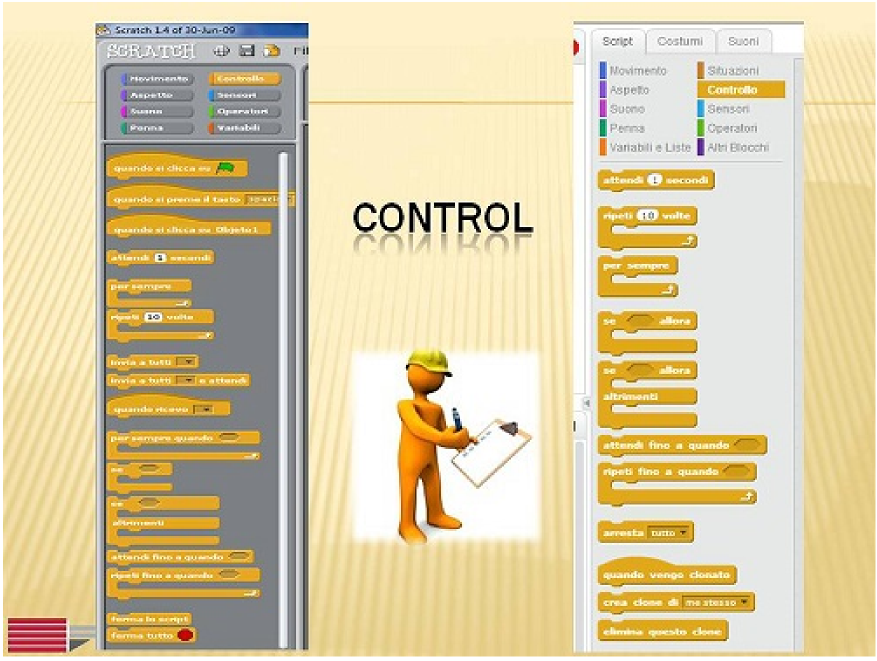

Fig. B.4 Control Category

Sensing. Fig. B.5

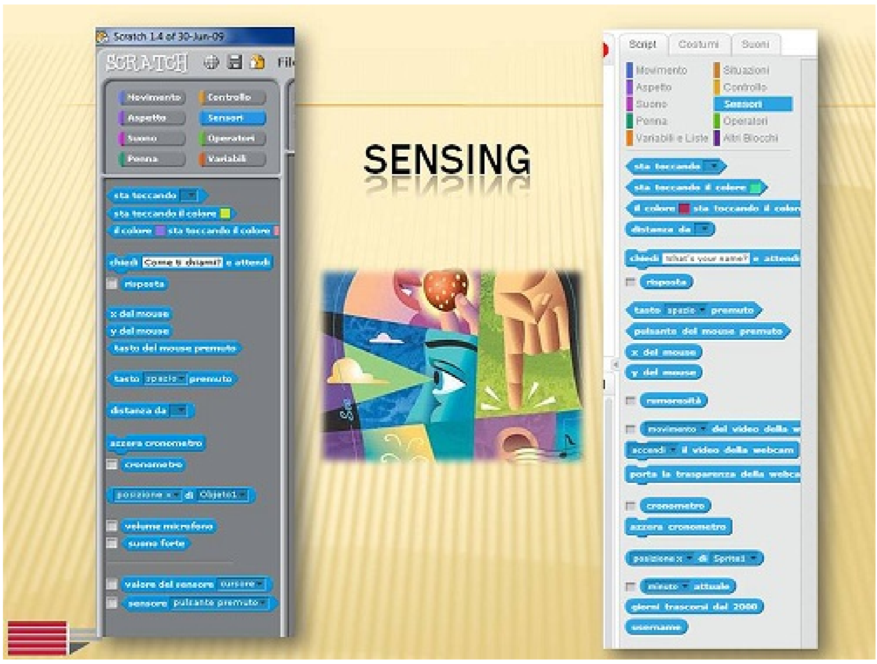

Fig. B.5 Sensing Category

Variables. Fig. B.6

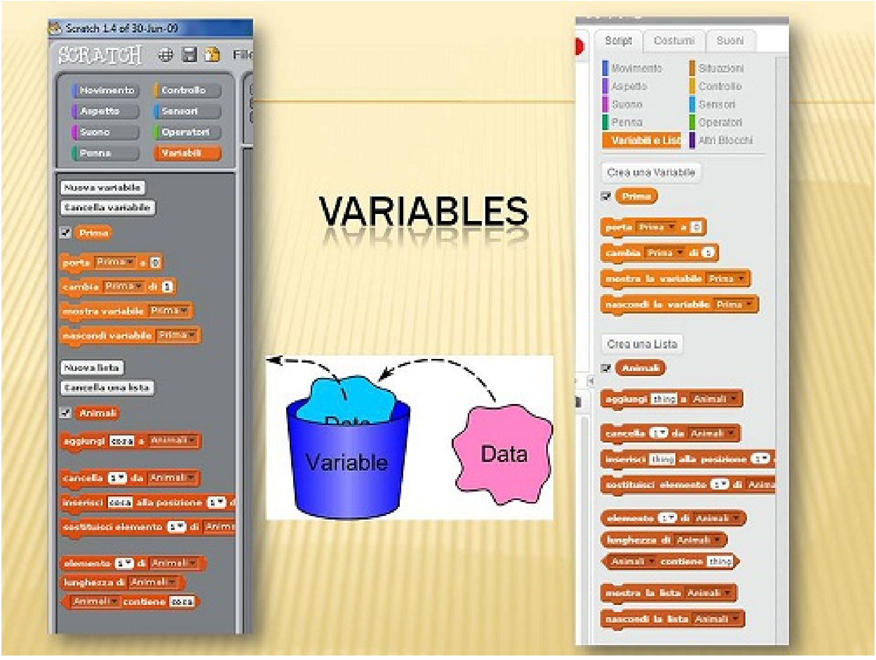

Fig. B.6 Variables Category

Extra blocks on Scratch version 2 and online version. Fig. B.7

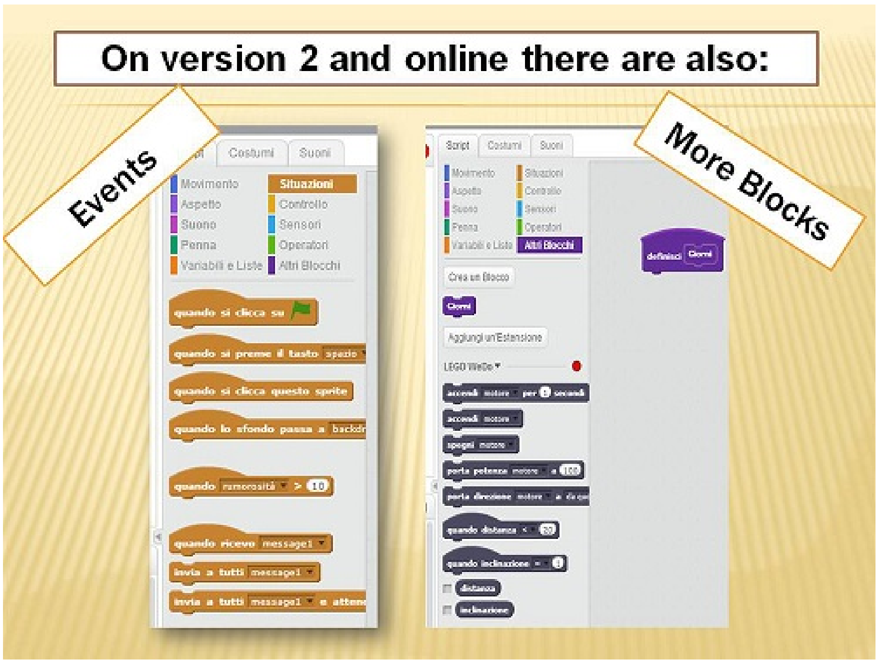

Fig. B.7 Events and More Blocks Categories

Scratch Applications

Fig. B.8 Different main screens of Scratch projects developed by Pre-service Teachers

Applications developed using Scratch

Fig. B.9 Screenshots of Applications developed in Scratch

Presentation and testing of Scracth Projects

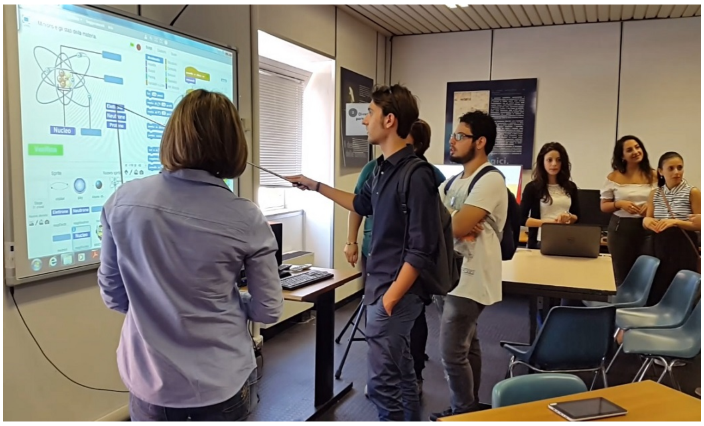

Fig. B.10 Presentation of the Scratch Projects in the Night of Researchers' event

Fig. B.11 Scratch project's testing

Fig. B.12 Scratch project's testing

Fig. B.13 Pre-service teachers

Fig. B.14 People testing projects

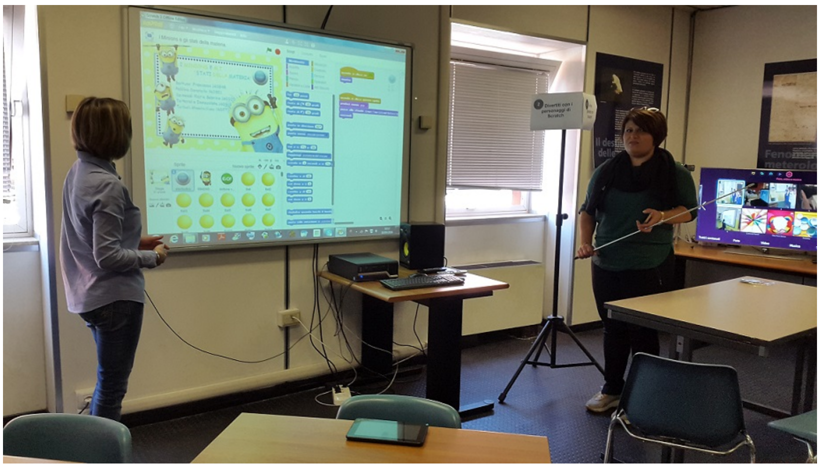

Fig. B.15 Interacting with Scratch

Appendix C

3D Scenarios in the "S-GAL" (Modeling, configuration and code)

Charles Darwin Research Station Scenario

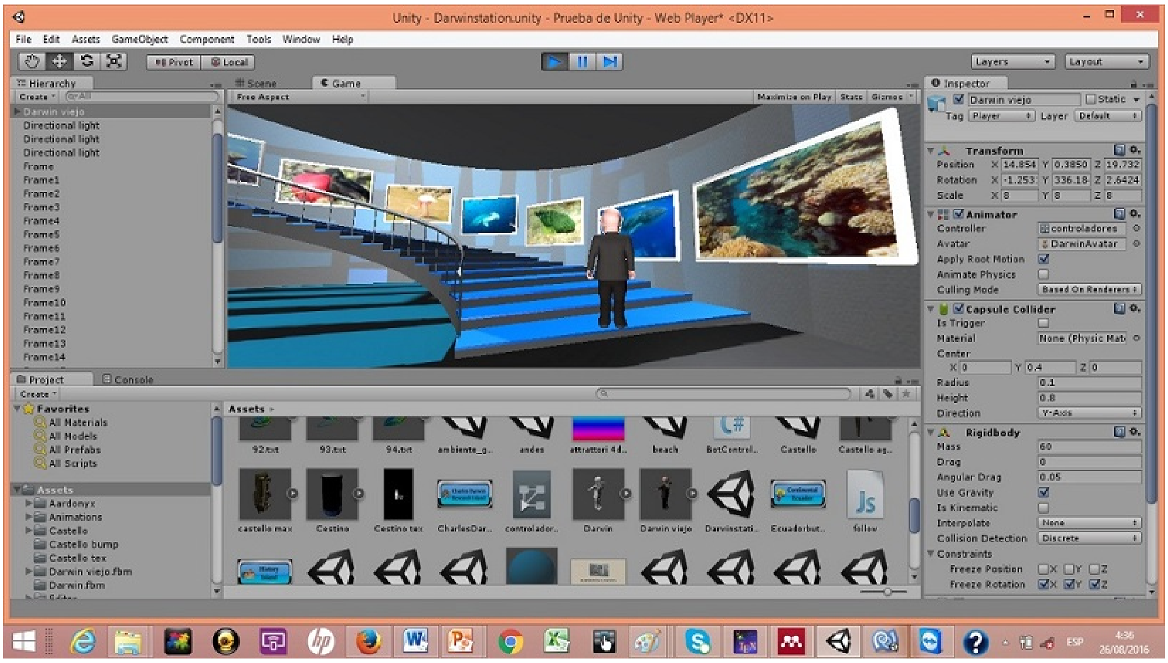

Fig. C.1 Charles Darwin Research Station Scenario

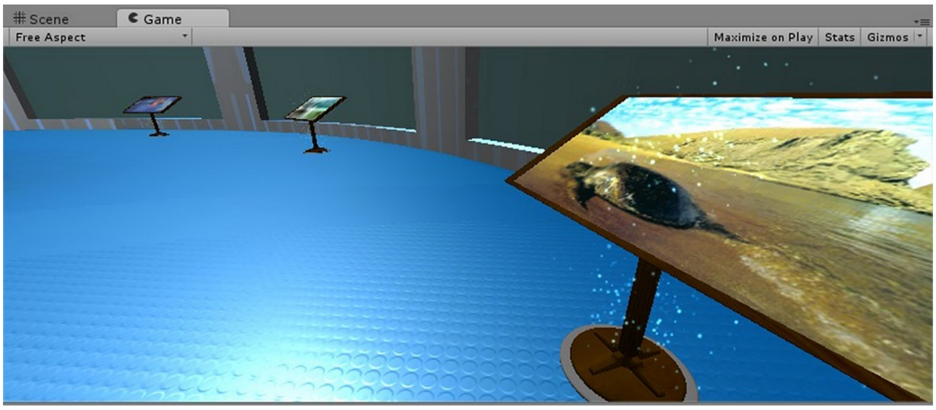

Fig. C.2 Charles Darwin Research Station Scenario.View 3

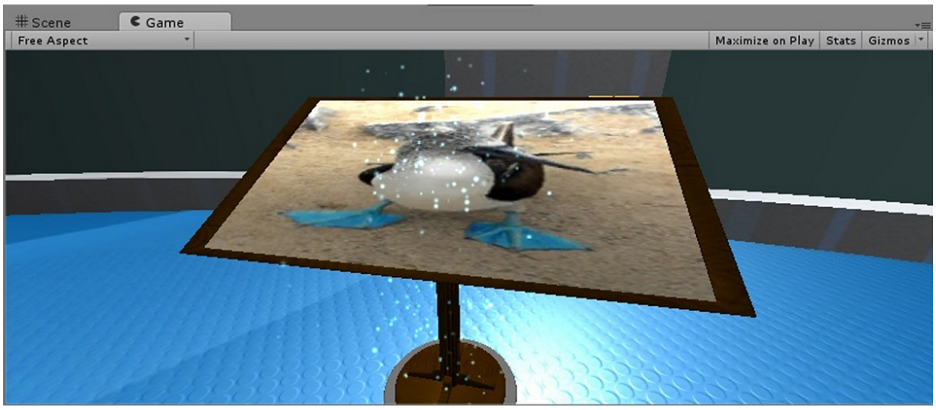

Fig. C.3 Charles Darwin Research Station Scenario. View 4

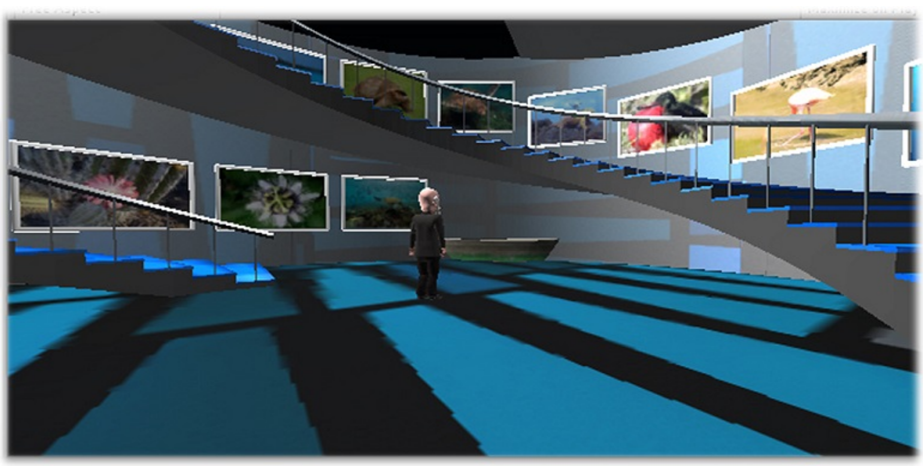

Fig. C.4 Charles Darwin Research Station Scenario. View 5

Third Scenario: Chaos Museum Island

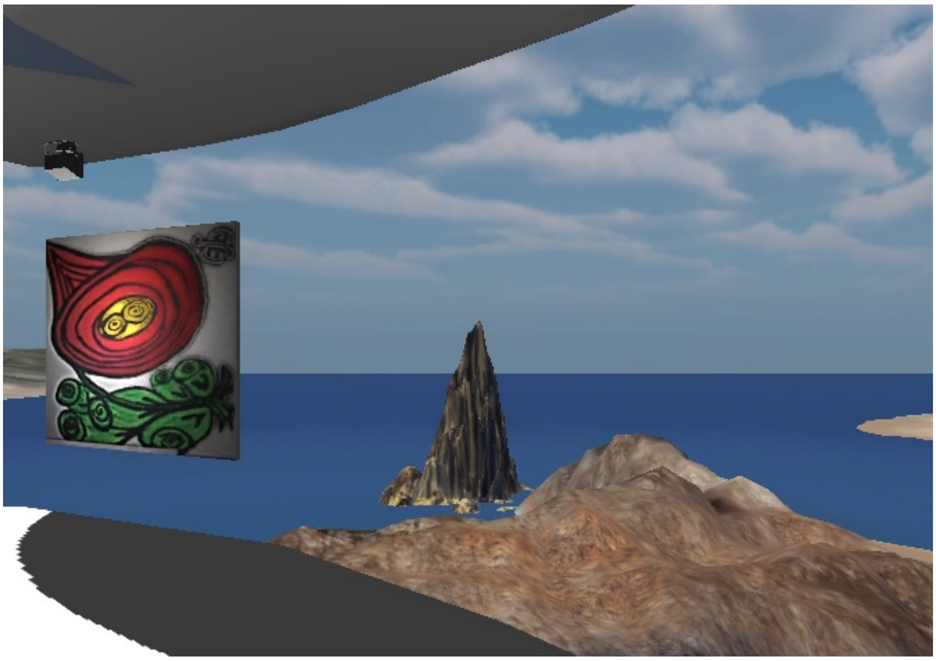

Fig. C.5 Chaos Museum Scenario. View 1

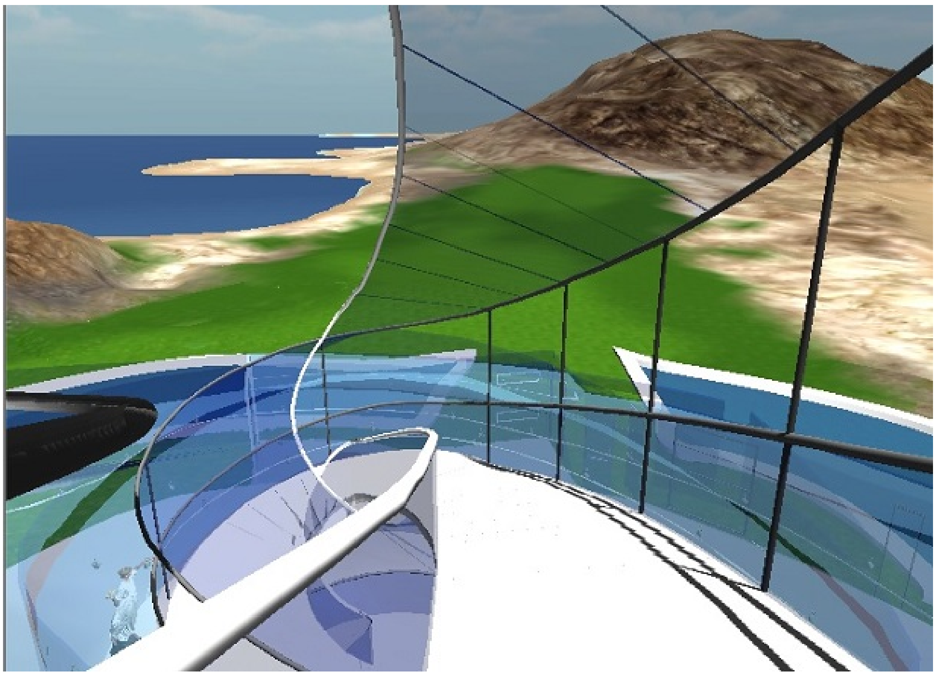

Fig. C.6 Chaos Museum Scenario. View 2

Fourth Scenario: History Island

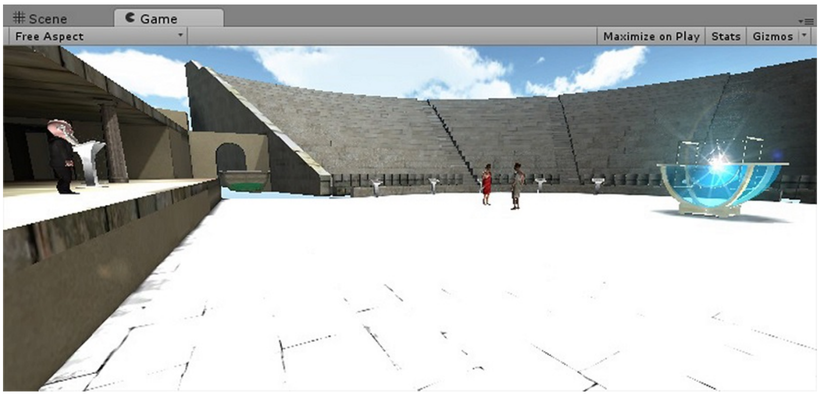

Fig. C.7 Histoy land where the Ancient Theater is located. View 3

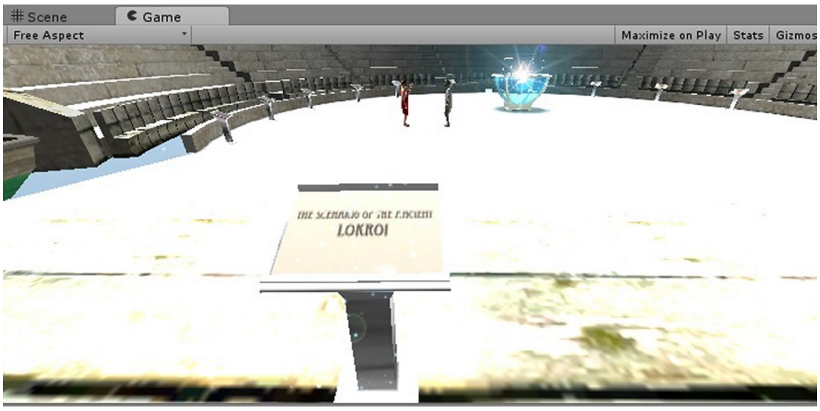

Fig. C.8 Histoy land where the Ancient Theater is located. View 4

Fig. C.9 Histoy land where the Ancient Theater is located. View 5

Fifth Scenario: Roman Castle Island

Fig. C.10 Roman Castle Scenario. Enter

Fig. C.11 Roman Castle Scenario. View 3

Fig. C.12 Roman Castle Scenario. View 4

Sixth Scenario: Continental Ecuador

Fig. C.13 Continental Ecuador Scenario. View2

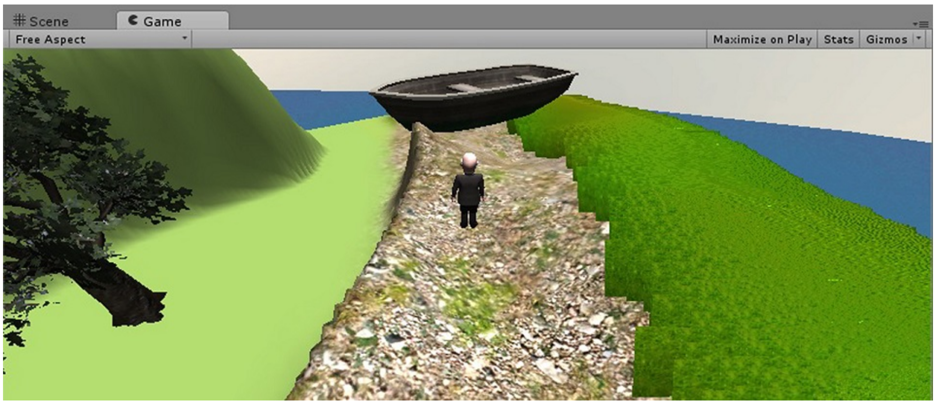

Fig. C.14 Continental Ecuador Scenario. View3

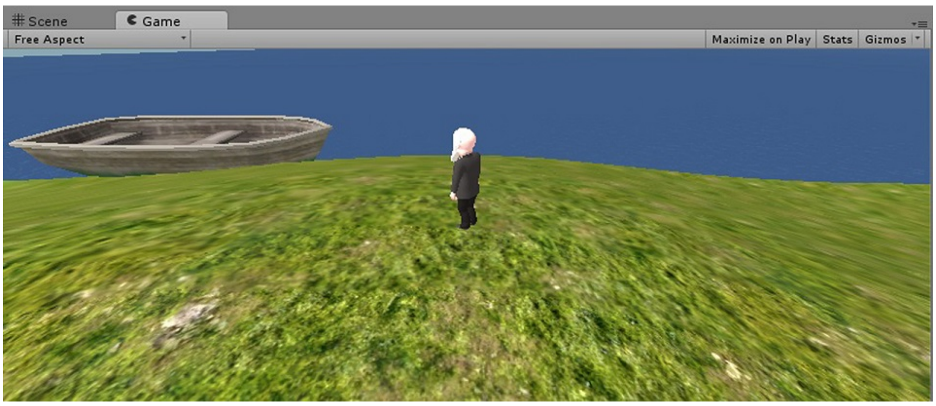

Fig. C.15 Continental Ecuador Scenario. Highlands. View 4

Darwin's avatar modeling and configuration

Fig. C.16 presents all the small parts of the model of Darwin's avatar, after this model was imported as a .FBX object into Unity 3D.

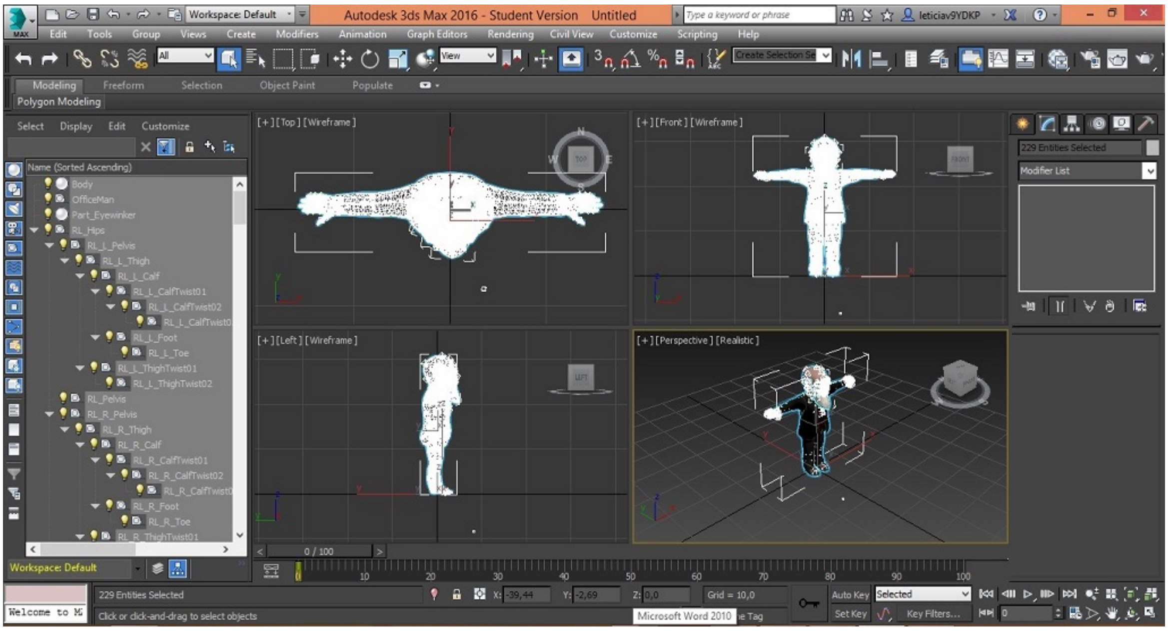

Fig. C.16 Darwin's avatar modeling

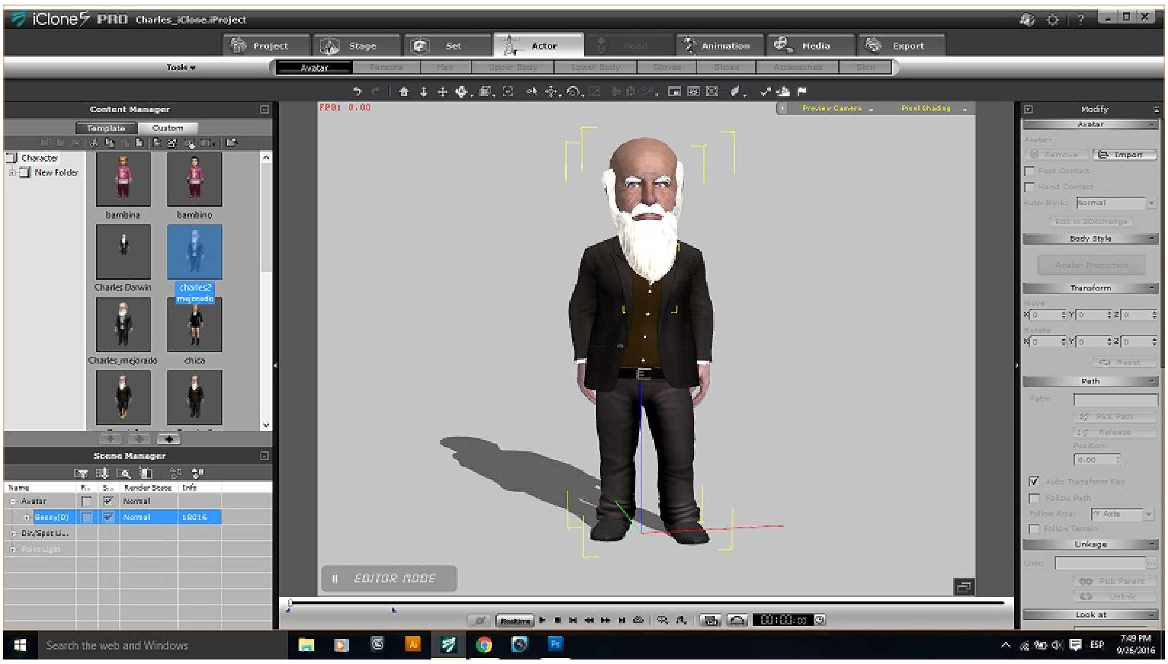

Fig. C.17 Darwin's avatar animation

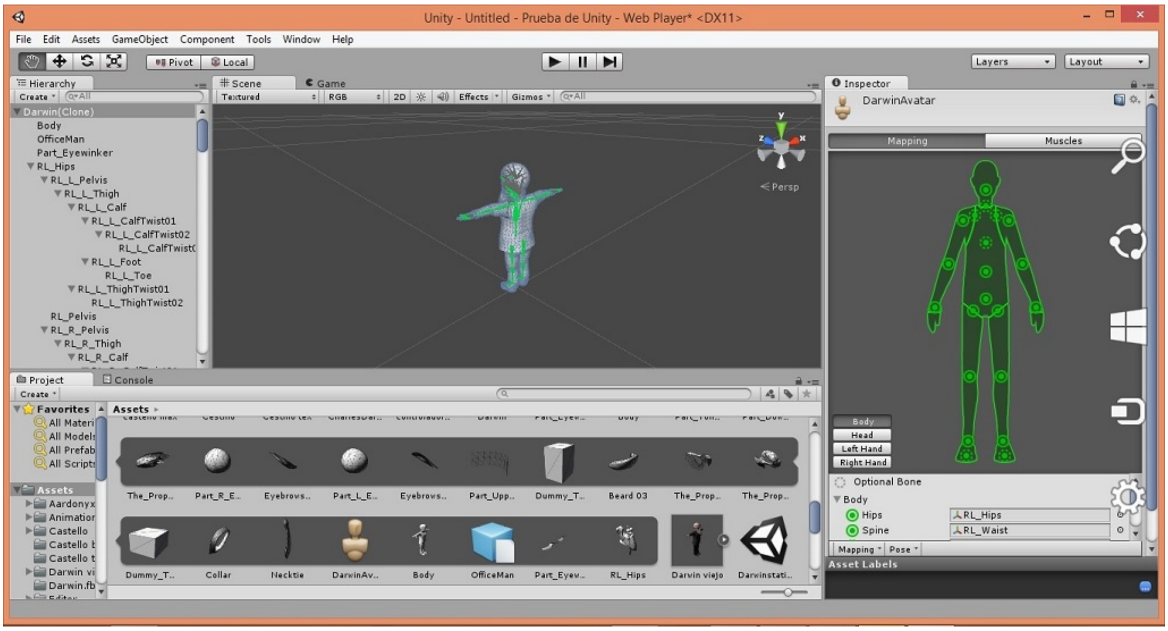

Fig. C.18 Darwin's avatar configuration in Unity 3D

In Fig. C.19 each one of the blocks control the avatar's movement, for instance Jump, walk-back, etc.

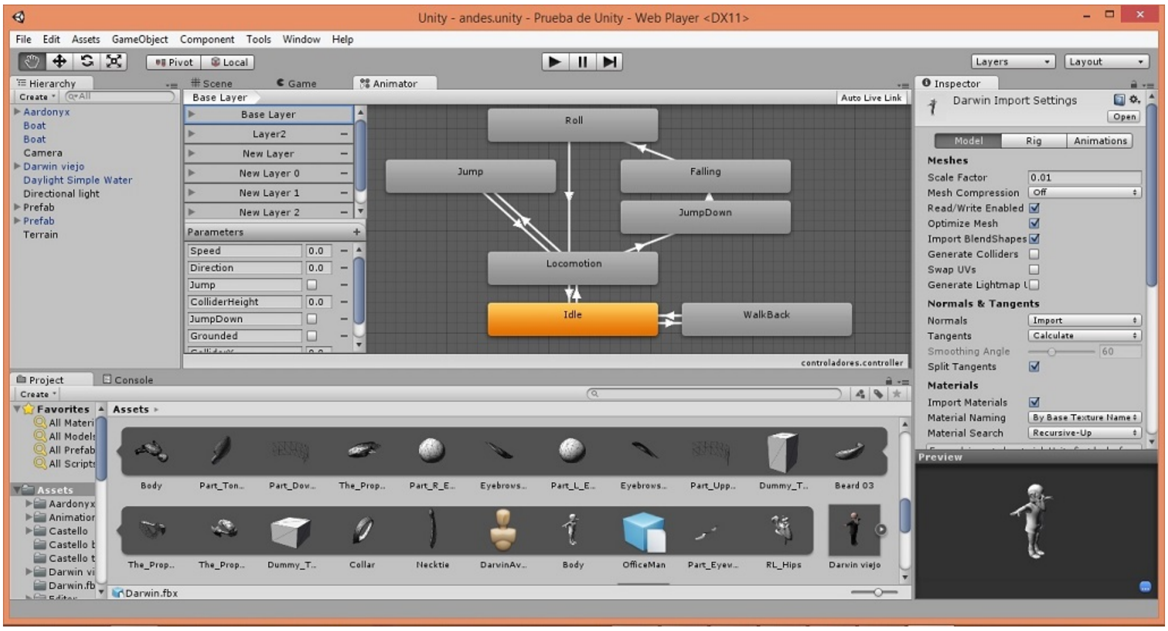

Fig. C.19 Motion configuration of Darwin's avatar in Unity 3D

Screenshots of the Darwin's game in Scratch

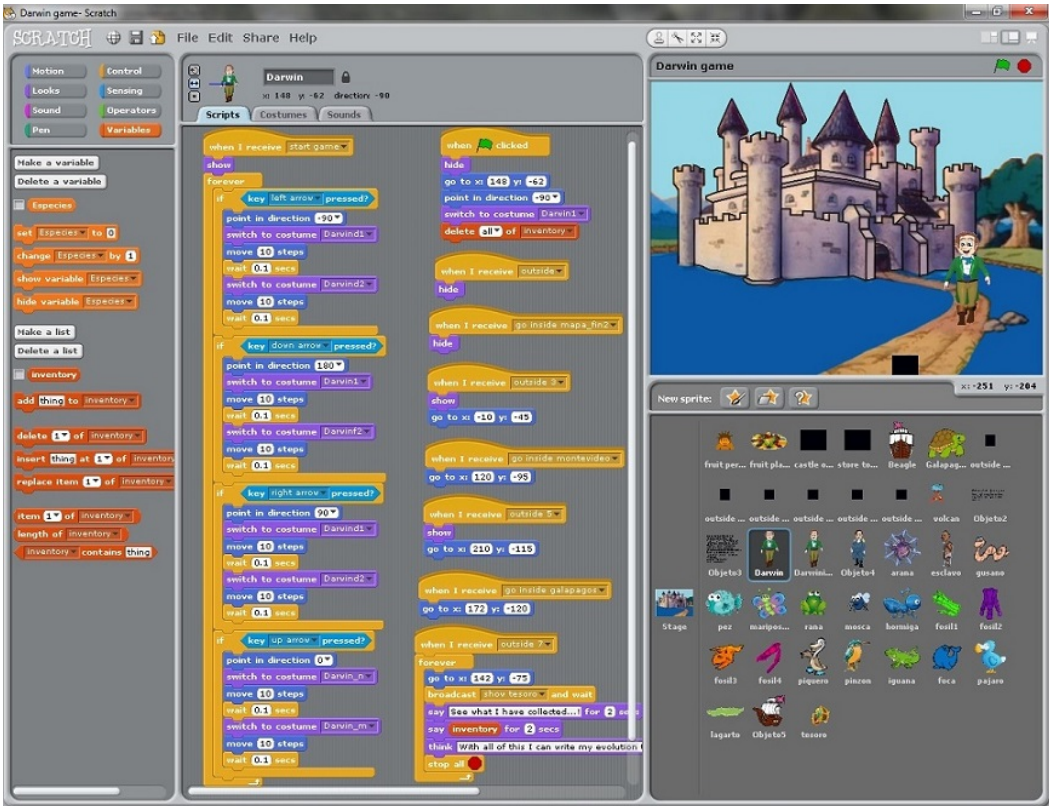

Fig. C.20 Darwin's game in Scratch with the sprites

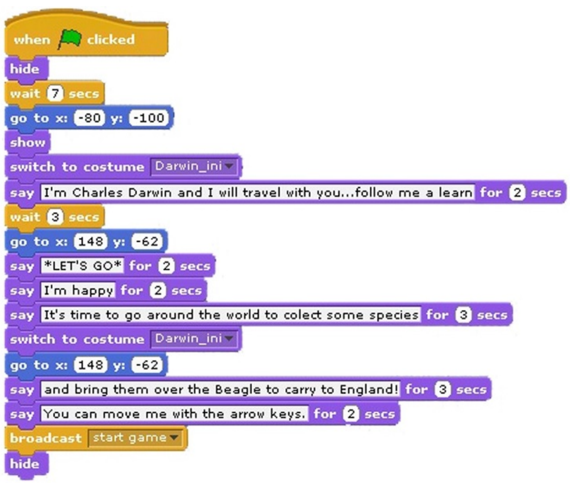

Fig. C.21 Script of Darwin's presentation in Scratch

In Fig. C.22 some of the sequences of images to simulate the movement and animation of the sprites in the Scratch game are presented. They gave an idea of the necessary work with each object used.

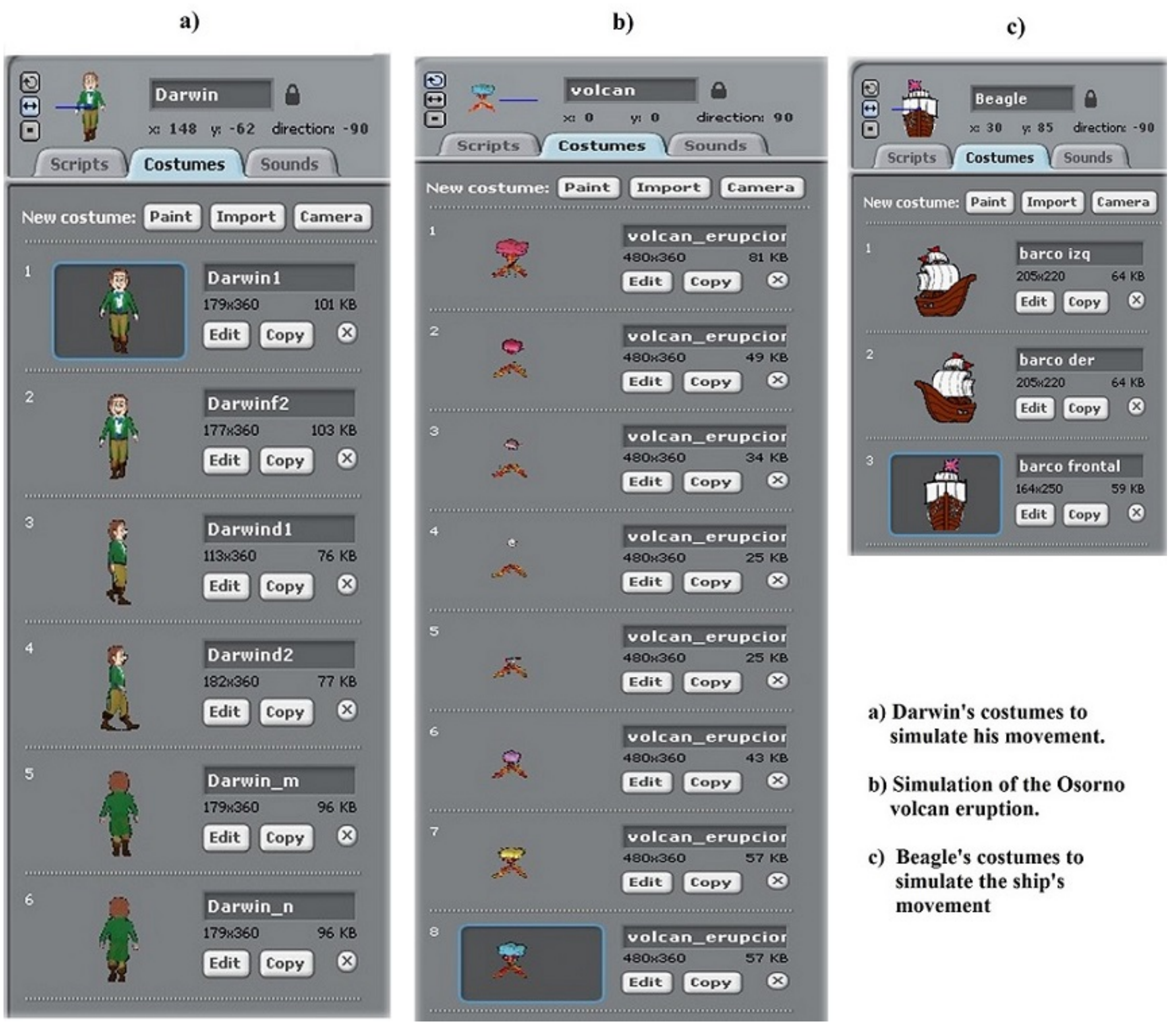

Fig. C.22 Some examples of costumes used in Darwin's games

Next Fig. C.23 shows the main scripts of the young Darwin movement in the Scratch game.

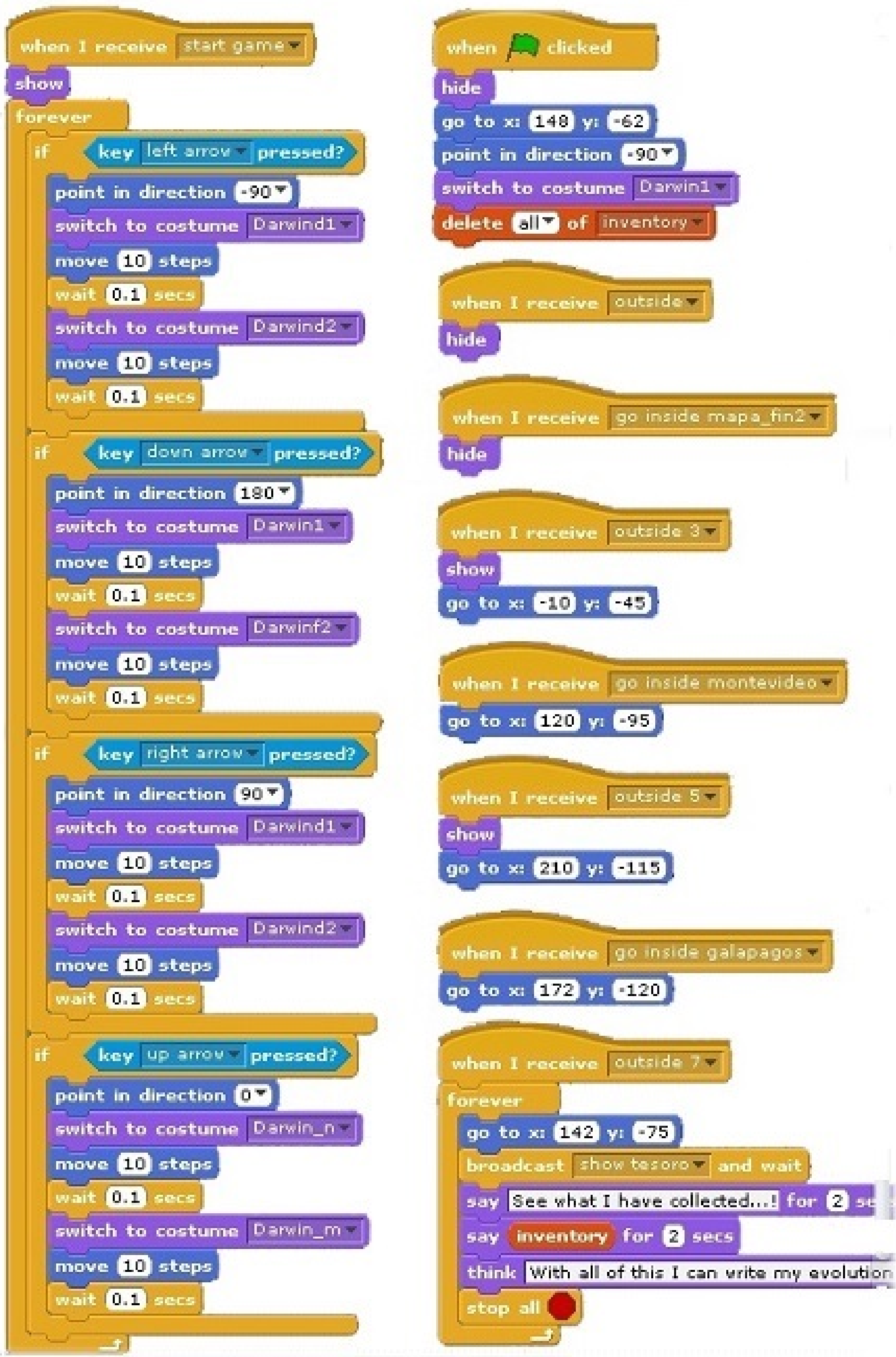

Fig. C.23 Some scripts of young Darwin Avatar in the scratch game