SolarSPELL Case Study: Pedagogical Quality Indicators to Evaluate Digital Library Resources

Lorena Alemán de la Garza, Marcela Georgina Gómez-Zermeño

Abstract—This paper presents the SolarSPELL case study that aims to generate information on the use of indicators that help evaluate the pedagogical quality of a digital library resources. SolarSPELL is a solar-powered digital library with WiFi connectivity. It offers a variety of open educational resources selected for their potential for the digital transformation of educational practices and the achievement of the 2030 Agenda for Sustainable Development, adopted by all United Nations Member States. The case study employed a quantitative methodology and the research instrument was applied to 55 teachers, directors and librarians. The results indicate that it is possible to strengthen the pedagogical quality of open educational resources, through actions focused on improving temporal and technological parameters. They also reveal that users believe that SolarSPELL improves the teaching-learning processes and motivates the teacher to improve his or her development. This study provides valuable information on a tool that supports teaching-learning processes and facilitates connectivity with renewable energies that improves the teacher training in active methodologies for ecosystem learning.

Keywords—Educational innovation, digital library, pedagogical quality, solar energy, teacher training, sustainable development.

I. INTRODUCTION

IN all countries, information and communication technologies (ICTs) have played a significant role in the generation and transmission of knowledge. Educational research projects about the use of ICT have driven innovations that contribute to the construction of new pedagogical theories [1]-[3]. The results report that technology applied in education strengthens the digital tools that are used by pedagogical modalities and educational systems to confront the socio-educational problems successfully and thus, achieve the Sustainable Development Goals set out in the 2030 Agenda, adopted by all United Nations Member States [4]-[6].

In the vast world of the information society, ICTs offer digital tools that can break the barriers of time and space. They provide new opportunities to access truthful and timely information [7], [8]. Through various electronic formats, the contents, texts, images, and videos, for example, are no longer prisoners of their physical origin or material characteristics. Separated from their physical essence, digital resources can be transmitted or consulted, regardless of the geographical place of the user who has an access device [9]-[12].

A. Digital Libraries

Within the universe of resources driven by ICTs, digital libraries emerge, intending to provide both tools and

Marcela Georgina Gomez Zermeño is with the Tecnologico de Monterrey, Mexico (e-mail: marcela.gomez@tec.mx).

specialized personnel to select, structure, distribute, control access, preserve the integrity and ensure persistence over time, so that digital collections are easily and economically available to be used by a defined community or set of communities [13]-[16]. A Digital Library is a tool that takes on the characteristics of physical libraries and reproduces them in a digital environment. It consists of databases that facilitate finding and accessing a limitless number of information sources. In lifelong learning, they occupy a central place, because they offer access to a wide variety of resources that contribute to strengthening both personal knowledge and collective intelligence with temporal and spatial convenience [17].

Although the definition of the concept of a digital library has been a matter of discussion, reviews of the literature turn up various definitions that have come to represent their essence and scope [18]. Thus, it is observed that a digital library can be defined as an organized collection of documents stored in digital format that offers information search and retrieval services [19], [20]. It can also represent a set of multimedia electronic resources (text, images, sounds, etc.) related to technical capabilities to create, search, and use the information [21]-[23]. One of the classic definitions of digital libraries suggested by the Federation of Digital Libraries contemplates a wide range of functions ranging from the selection, structuring, and preservation to the interpretation and offering of digital resources for easy and economic access to the user communities [15], [24], [25].

B. Indicators of Pedagogical Quality of the Bibliographic Resources

A digital library houses a collection of objects, also called items, resources, or materials, and among these are books, newspapers, documents (e.g., pages in HTML format), as well as various multimedia objects (e.g., paintings or images, tapes, or video files). It is becoming more and more difficult to establish criteria for the classification of resources in a digital library; for example, hypertexts cannot be collected because they constitute countless references, nor can they be determined because of their mutable nature. That is why establishing the basis of a model for assessing the pedagogical quality of bibliographic resources in electronic format requires understanding that the qualities of the information objects in electronic format are ephemeral, not fixed [26]-[28].

Currently, new media and information objects have forced the establishment of new reference systems that are generally adaptations of the standards used in bibliographic materials. Establishing a typological classification of bibliographic resources in digital format is not a simple task due to the

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continuous changes that occur in such a dynamic environment. Analyzing the characteristics of the resources that make up the digital libraries involves reviewing their quality. According to [11], the evaluation of the quality of information resources in electronic format requires detailed planning that involves two key elements:

- *Parameters:* Generic aspects that will be evaluated. It is a question of establishing blocks on which the analysis will be carried out and which will be developed into specific indicators that give the necessary information for each of these groups.
- *Indicators:* Elements that develop each of the parameters established for the analysis of information. These are the specific issues that will be evaluated.

In assessing the quality of information resources in electronic format, [27] managed more than 125 indicators, which were subsequently grouped into eleven parameters: 1) Accessibility and usability of the site; 2) Identification of the resource and its documentation, 3) Identification of the author; (4) Authority of the author; 5) Design and structure of the information; 6) Relevance and scope of content; 7) Validity of the content; 8) Accuracy and reliability of the content; 9) Navigation within the document; 10) Quality of the links; 11) Aesthetic and affective aspects.

Cooke [36] proposes ten parameters that he considers to be characteristic of any information resource in electronic format: 1) Purpose; 2) Coverage; 3) Authority and reputation; 4) Accuracy; 5) Updating and maintenance; 6) Accessibility; 7) Presentation and organization of information; 8) Ease of use; 9) Comparison with other sources; 10) Overall resource quality. For his part, Codina [29] considers that any attempt to review information should focus on content and authorship. He initially proposed 14 indicators that were subsequently grouped into six parameters [30], [31]:

1. *Authorship:* adequacy and solvency of the source
2. *Content*: intrinsic value and volume of information
3. *Access to information:* navigation and retrieval
4. *Ergonomics:* comfort and ease of use
5. *Luminosity:* presence and quality of external links
6. *Visibility:* The number of links received from other resources

Previous studies have analyzed the factors involved in the successful implementation of digital libraries and report important findings related to the needs of the users to leverage these resources better. Khan [32] mentions that digital skills are required for users, and these can be strengthened through training. His study in Pakistan found that one of the barriers to use is poor internet facilities. Also, often users do not know how to use the resources and the services offered [33]. On the other hand, [34] indicates that it is necessary to integrate into the digital libraries the educational activities that use technology to generate social ownership of knowledge. However, this integration must be planned so that it contributes to the attainment of the educational goals.

Cleveland [21] notes that a quality digital library offers a select collection with a well-defined purpose, targeting populations of users who need determined information.

However, it will never be able to become a system that offers instant access to all kinds of resources to all the populations of information anywhere in the world. This reflection underpins the research question posed for this case study: "What indicators can improve the pedagogical quality of the open educational resources offered by the SolarSPELL digital library implemented in rural primary schools in the Fiji Islands"?

II. METHODS

Recognizing the methodological challenges posed by the evaluation of the pedagogical quality of the resources in an electronic format that makes up a digital library, the working group that participated in the SolarSPELL pilot implementation selected a research design based on a case study that would apply a quantitative approach. For [35], the case study is a type of research particularly appropriate for studying a phenomenon intensely in a short time. It represents a research strategy of various dynamics in singular contexts, and its potential lies in its focus on the object of study to generate information on the processes with which it interacts [36].

Korzilius [37] explains that case studies using quantitative analysis present their own elements to the empirical-analytical scientific approach. It is a method for examining a complex phenomenon based on a comprehensive understanding of the object of study and its context [38]. Although there is a debate on the application of the quantitative approach in a case study, [39] argues that case studies can be based entirely on quantitative evidence. He emphasizes that the research questions and the data collected will be crucial to generating information that explains the phenomenon under study.

A. Research Instrument

In order to generate information to assess the pedagogical quality of the open educational resources that the SolarSPELLs implemented in the Fiji pilot offered, we reviewed various instruments that have been successfully used in educational research projects. Based on the research question, an instrument designed by [11] was selected, suitable for [40]-[42] and published by [2]. "DIAPASON" is a research instrument composed of 50 indicators that allow for the collection of data in order to assess an educational resource with pedagogical, functional, technological, temporal, and globally perceptive parameters [2], [41]:

a) *Pedagogical:* 19 indicators for collecting data that allow assessing the indicators related to databases (contents), learning resources, the pedagogical approach, adequacy and adaptation by the users, motivational capacity, the tutorial, and evaluation.
b) *Functional:* Six indicators for collecting data that allow assessing indicators related to user autonomy and control, ease of use, and the functionality of the documentation.
c) *Technological*: 13 indicators to collect data that allow evaluating indicators related to the visual environment, design and technology, versatility, *navigation, interaction, and dialogues.*

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d) *Temporal:* Six indicators to collect data to assess indicators related to the calendar, the time allowed to study the topics, carry out the activities, do the exercises, take the exams, and participate in the discussion forums.

e) *Global Perception:* Data collection for six indicators that allow comparing an educational resource based on the use of technology with printed material, to consider the time it requires to know a topic, the possibility of completing different activities, time optimization, the diversity of resources to explain a topic, the improvement in the process of teaching/learning, and the development of teacher skills.

B. Context and Object of Study

SolarSPELL (Solar Powered Educational Learning Library), is an offline digital library that works with the electrical energy generated by its solar cells, so no additional external electricity source is required [43], [44]. Like most computer equipment, it consists of a processor (CPU), RAM, HDMI, USB port, Ethernet, and a WiFi access point, to which any device with WiFi capabilities, such as a smartphone, tablet, or laptop, can be connected (Fig. 1).

Fig. 1 SolarSPELL

The SolarSPELL digital library offers a wide variety of open educational resources that contribute to the digital transformation of educational practices, which were selected for their capacity to help achieve the Sustainable Development goals set out in the 2030 Agenda. These resources are categorized into seven categories, namely, creative arts, environment, health and safety, language arts, mathematics, sciences, and local topics.

This educational innovation was developed by a team of academic-practitioners and university-level students, to enable the provision of digital libraries in schools of marginalized communities or rural populations, no matter their infrastructural challenges or prior exposure to ICTs [1], [40]. Since 2015, SolarSPELL libraries have been successfully implemented in rural schools in the following countries: Fiji, Vanuatu, Samoa, Tonga, Micronesia, Comoros, Rwanda, and South Sudan.

The SolarSPELL library provides content that is open access, digitized, educational, and localized as much as possible, in order to increase potential interest and engagement by students and teachers, as well as to be respectful of language, socio-cultural norms, and educational emphases. In the case of Fiji, SolarSPELL team had been requested to provide resources related to climate change on the library [45], [46]. Fiji's Ministry of Education, Heritage and the Arts

(MEHA) had made its textbooks available online, so the SolarSPELL team prioritized working with the Ministry to create climate change-focused lesson plans that drew from the textbooks but also made use of supplemental information within the library.

The SolarSPELL team traveled to Fiji in July 2018 to carry out a pilot-level training with teachers and Peace Corps volunteers from four primary schools and returned to Fiji in August 2019 to carry out a train-the-trainer training with a larger cohort of teachers and PCVs, representing 16 rural schools from across the country. In the interim between the two trainings, the SolarSPELL team worked to improve the content of the Fijian library, with additional climate change-related content [47], [48]. The results of this article, presented below, are from data gathered in February 2020, from the schools that had received a SolarSPELL digital library, and who had sent two teachers to take part in a train-the-trainer training, in August 2019. Thus, the results reflect indicators gathered six months after the training had taken place.

III. RESULTS

During the activities carried out to evaluate the pedagogical quality of the open educational resources that make up the SolarSPELL digital library, the work team visited seven rural schools located in the Islands of Vanua Levu and Viti Levu. For the most part, the participating schools are located in rural communities that lack electricity, internet, and public transport. The visit requires several hours of travel by air, sea, and winding dirt roads.

Before the fieldwork, the teacher-researchers explained in detail the instruments for the evaluation of the open educational resources, and they invited all of the educational figures who comprise the academic community to participate voluntarily. Each school's facilities were also visited to collect data on the printed bibliographic resources they offer. Thus, it was observed that some schools have a library, but most of their materials are outdated and not sufficient to support students in the different educational levels (Fig. 2).

Fig. 2 Pilot project carried out in rural schools in Fiji

A. Results of the Set of Indicators for the Assessment of Pedagogical Quality

In order to collect data on the open educational resources offered by SolarSPELL, the DIAPASON instrument was applied to a total of 55 teachers, directors, librarians, and facilitators. This instrument is composed of 50 indicators that

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assess the pedagogical, functional, technological, and temporal quality and the overall perception of the resources. It is based on a five-point Likert scale with answers rating agreement with the 50 items as follows: 4 = Totally Agree, 3 = Ok, 2 = Sometimes Agree, 1 = Disagree, 0 = Total Disagreement.

It was obtained a mean of 3.14 for all the indicators and the highest result of 3.38, corresponding to indicators of overall perception parameter (Fig. 3). These perception indicators request the participants to compare a SolarSPELL educational resource with a printed textbook, with the time it requires to know a topic, the possibility of performing different activities, time optimization, the diversity of resources to explain a topic, improvement of the teaching-learning process, and the development of teaching skills.
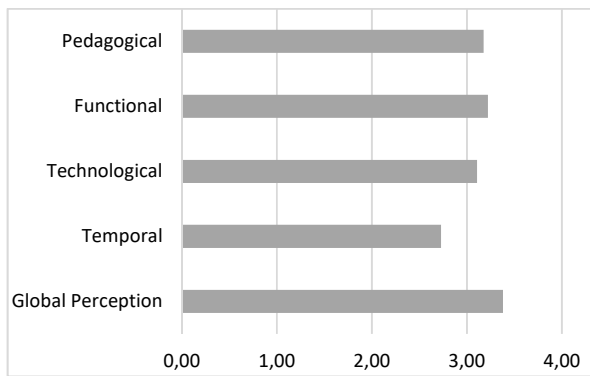

Fig. 1 Evaluation results of the DIAPASON parameters

B. Pedagogical Parameters

For the 19 indicators related to the "Pedagogical" parameter, a mean of 3.18 was obtained, and the results range from 2.92 to 3.42. Upon analyzing each category, we find that the highest mean corresponds to the indicators about the "Contents Base" (3.32) and the "Pedagogical Focus" (3.25), while the lowest category rated in the indicators was "Adequacy and adaptation to the users" (3.03).

As can be seen in Table I, the indicators that obtained the highest means in the category "Base of Contents" are related to "The topics are developed with clarity using precise words" (3.42) and "The topics of the library are explained in detail" (3.33). In the "Pedagogical Focus" category, the highest results were obtained in the indicators for "The activities and exercises develop self-learning" (3.38), followed by "The activities and exercises develop critical thinking" (3.23).

Table I shows that in the "Content Base" category, 94.34% of participants agree that "The topics of the library are developed clearly, using precise words", and 85.19% say that "The topics of the library are explained in detail". In the "Resources" category, 90.20% agree that "The activities present an introduction to the "topics" and 80.77% that "The activities present a synthesis of the topics".

It should be noted that "Pedagogical Focus" is the indicator related to self-direction; 92.31% of participants agree that "The activities and exercises develop abilities to strengthen teacher practice", while 90.39% consider that "The activities and exercises develop self-learning". It is also noteworthy that

84.91% of participants say that "The activities and exercises are focused on the achievement of the learning outcomes", while 83.02% agree that "The activities and exercises develop critical thinking".

TABLE II
RESULTS OF THE INDICATORS FOR THE "PEDAGOGICAL" PARAMETER

Category	Mean	Indicators	Mean
Contents base	**3.32**	1 The topics of the library are explained in detail.	3.33
		2 The topics are developed clearly, using precise words.	**3.42**
		3 The topics are well structured and have a logical order.	3.21
Resources	3.13	4 The activities present an introduction to the topics.	3.18
		5 The activities present a synthesis of the topics.	3.06
		6 The activities offer resources that facilitate the comprehension of the topics.	3.15
Pedagogical focus	3.25	7 The activities and exercises are focused on the achievement of the learning outcomes.	3.13
		8 The activities and exercises develop critical thinking.	3.23
		9 The activities and exercises develop self-learning.	3.38
		10 The activities and exercises develop abilities to strengthen teacher practice.	3.27
Adequacy and adaptation to the users	**3.03**	**11 Extension, structure, depth, and vocabulary of topics are adequate.**	**2.92**
		12 The activities considered the knowledge, skills, interests, and needs of the participants.	3.13
Motivational Capacity	3.18	13 The activities and exercises keep the participant's attention.	3.19
		14 The activities and exercises motivate the participant to investigate.	3.19
		15 The activities and exercises stimulate creativity.	3.25
		16 Assessments are challenging and consider the knowledge of the participants.	3.10
Tutorial and evaluation	3.06	17 Assessments offer feedback.	3.02
		18 The exercises offer tutorials with orientation, aids, and reinforcements to the participants.	3.00
		19 The SolarSPELL team brings adequate support to resolve concerns or questions.	3.17

C. Functional Parameters

TABLE II
RESULTS OF THE INDICATORS FOR THE "FUNCTIONAL" PARAMETER

Category	Mean	Indicators	Mean
Autonomy and control of the user	**3.26**	**20 The activities offer links to deepen the topics.**	**3.26**
		21 The instructions in the exercises are clear and easy to understand.	**3.26**
Ease of use	3.18	22 The resource access instructions are clear and easy to understand	3.17
		23 It is easy to access lesson plans, activities, exercises, assessments, and resources.	3.18
Functionality of the documentation	**3.12**	**24 When presenting the topics, the references are indicated.**	**3.12**
		25 The activities suggest the use of complementary documentation (readings, open resources, blogs, wikis).	**3.11**

The mean was 3.22 for the six indicators related to the "Functional" parameter, and the results range from 3.11 to 3.26. Table II shows that the highest mean corresponds to the category "Autonomy and user control" and the lowest is "Functionality of the documentation". Also, we note that 88.68% of the participants indicated that "The activities offer links to deepen the topics" and "The instructions in the exercises are clear and easy to understand". Regarding the

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"Ease of Use", 86.80% state that "The resource access instructions are clear and easy to understand", and 80.40% express that "It is easy to access the lesson plans, activities, exercises, assessments, and resources".

D. Technological Parameter

For the 13 indicators related to the "Technological" parameter, the mean was 3.11, with the range of means from 2.29 to 3.62. As can be seen in Table III, the highest mean of 3.34 corresponds to the category "Visual environment" and the lowest (2.31) to the category, "Interaction and dialogues".

TABLE III
RESULTS OF THE INDICATORS FOR THE "TECHNOLOGY" PARAMETER

Category	Mean	Indicators	Mean
Visual environment	**3.34**	26 The visual quality of the texts (typography, distribution, colors) is adequate.	3.33
		27 The technical and aesthetic quality of multimedia materials is adequate.	3.06
		28 It integrates a variety of multimedia resources (videos, audio, images, animations, and texts).	**3.62**
Design and technology	3.27	29 Graphic design is attractive, and the resources are dynamic.	3.42
		30 The activities use advanced technologies (multimedia, animations, open resources).	3.27
		31 The use of the Solarspell is reliable because it has no technical failures.	3.13
Versatility	3.20	32 The font size, colors, and resolution of the images can be adjusted.	3.08
		33 Access to open educational resources is offered.	3.31
Navigation	3.18	34 The navigation in the pages is structured, simple, and ergonomic.	3.30
		35 The navigation between the lesson plans, activities, exercises, and resources is fast.	3.06
		36 There is a direct link to the homepage from any page of the course.	3.19
Interaction and dialog	**2.31**	37 Communication media are used by the participants (blogs, emails, WhatsApp, etc.).	2.33
		38 Communication media are used between participants and tutors (forums, communicated, etc.).	**2.29**

We note that 92.31% of participants consider that "It integrates a variety of multimedia resources (videos, audio, images, animations, and texts)," and 86.27% agree that "The visual quality of the texts (typography, distribution, colors) is adequate". In the "Design and Technology" category, 88.47% say that the "Graphics design is attractive, and the resources are dynamic", and 84.61% indicate that "The activities use advanced technologies (multimedia, animations, open resources). Regarding the "Versatility" category, 84.62% appreciate that the "Access to open educational resources is offered", and in the "Navigation" category, 86.80% consider that "The navigation in the pages is structured, simple, and ergonomic", followed by 86.54% that "There is a direct link to the homepage from any page of the course".

E. Temporal Parameter

For the six indicators related to the "Time" parameter, the mean was 2.73, and the results ranged from 2.61 to 2.92. Note that the highest average corresponds to the category, "Study topics", and the lowest is "Participates in discussion spaces". Although 70.59% of the participants consider that "The

suggested procedure agenda helps in planning the time expected to dedicate to the course", as also "The indicated time to study the topics of the lesson plans is sufficient", only 56.87% consider that "The time indicated to carry out the exercises is sufficient" and "The time indicated to present the assessment is sufficient".

TABLE IV
RESULTS OF THE INDICATORS FOR THE "TIME" PARAMETER

Category	Indicators	Mean
Calendar / Agenda	39 The suggested procedure agenda helps plan the time expected to be dedicated to the course.	2.76
Study topics	**40 The indicated time to study the topics of the lesson plans is sufficient.**	**2.92**
Do activities	41 The time indicated to carry out the activities is sufficient.	2.75
Do exercises	42 The time indicated to carry out the exercises is sufficient.	2.65
Present the self-diagnostics	43 The time indicated to present the assessment is sufficient.	2.67
Participates in discussion spaces	**44 The time indicated to participate in discussion spaces is sufficient.**	**2.61**

F. Overall Perception of SolarSPELL Compared to Printed Textbooks

For the 19 indicators related to the overall perception expressed by the users about SolarSPELL, the mean was 3.38. The highest mean is found in the indicators related to the category "Pedagogical focus" at 96.15% for the item, "In comparison with a printed textbook, SolarSPELL generates greater interest in strengthening teacher development". The statement, "In comparison with a printed textbook, SolarSPELLs improves the teaching-learning process", scored 90.39%.

TABLE V
COMPARISON RESULTS BETWEEN SOLARSPELL AND PRINTED TEXTBOOKS

Category		Indicators	Mean
Time	**3.25**	**45 In comparison with a printed textbook, SolarSPELL requires less time to know a topic.**	**3.24**
		46 In comparison with a printed textbook, SolarSPELL facilitates doing different activities at the same time.	3.25
		47 In comparison with a printed textbook, the SolarSPELL course lets me optimise the time.	3.25
Pedagogical approach or focus	3,.51	48 In comparison with a printed textbook, SolarSPELL offers different resources to explain a topic.	3.42
		49 In comparison with a printed textbook, SolarSPELL improves the teaching-learning process.	3.46
		50 In comparison with a printed textbook, SolarSPELL generates greater interest in strengthening teacher development.	**3.65**

IV. CONCLUSION

As can be seen in this case study, the development of digital libraries and the need for their study are not isolated facts but fostered by a series of technological, educational, and social causes and conditions. While it is true that their study has generated contributions that improve the quality of the resources offered by these technological tools, we must recognize that these efforts have not had the same momentum at all levels of education. Therefore, the challenge of a digital

library for primary education, apart from having to consider the skills of the entire academic community, involves considering the need for their uses, the access to information and the cognitive development of all its users.

Applying a research instrument that integrates a set of indicators to assess an educational resource with pedagogical, functional, technological, temporal, and overall perception parameters led to the generation of relevant information that strengthened the pilot implementation of SolarSPELL. This research provides knowledge about the use of indicators to design and implement actions focused on improving digital libraries to enhance their resource benefits for academic communities. Education should be conceived as an area of study that shifts on par with the movements of science and technology. It helps to position digital libraries, as entities that contribute to materializing the opportunities offered by ICTs in the development of people in the context in which they interact. Emphasize the need for the librarian of the future and educational figures to conceive of his academic work by incorporating the new paradigm of digital.

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Lorena Alemán de la Garza is a PhD in Education and ICT (e-learning) from the Open University of Catalonia (UOC), a Master in Administration of Educational Institutions from the Tecnológico de Monterrey obtaining the "Honorable Mention of Excellence" and a Bachelor of Business Administration from the TecMilenio University where he also obtained the "Honorable Mention of Excellence". Professor-researcher at the School of Humanities and Education at the Tecnológico de Monterrey, she participates in the Doctorate programs in Educational Innovation, Master in Education, Master in Educational Technology and Master in Administration of Educational Institutions. Coordinates Continuing Education, Consulting and Extension activities, in which the Teacher Training, Educational Innovation, Innovative Learning Environments, Instructional Design for Active Learning and Administration of Educational Projects based on the use of Technology. Member of the National System of Researchers (SNI) of the National Council of Science and Technology (CONACyT), of the Mexican Council of Educational Research (COMIE) and of the American Educational Research Association (AERA). Technical manager in projects of CONACyT, associate researcher in projects of the European Commission (ALFA Program) and CONACyT Thematic Networks "Complexity, Science and Society",

"Convergence of knowledge for the benefit of society". Co-author on the "Techbook" project of the Mahatma Gandhi Institute of Research for Education for Peace and Sustainable Development (MGIEP) of the United Nations Educational, Scientific and Cultural Organization (UNESCO) and invited lecturer at UNESCO's Mobile Learning Week - Paris Headquarters.

Marcela Georgina Gómez-Zermeño is a PhD in Educational Innovation from the Tecnológico de Monterrey with Honorable mention of Excellence. Master of Science in Engineering in Computer and Communications Technologies from the Higher School of Electrical and Electronic Engineers of Paris, France. Bachelor of Computer and Administrative Systems from the Tecnológico de Monterrey, Monterrey Campus. Research professor at the School of Humanities and Education at the Tecnológico de Monterrey in the Doctoral programs in Educational Innovation, Master in Educational Technology and Master in Education. Member of the Strategic Focus Research Group "Research and Innovation in Education", with the lines: "Development and Use of Technology in Education". Former Director of the Center for Research in Education at the Tecnológico de Monterrey. Former Editor of the "Educational Research Magazine of the Graduate School of Education (RIEEGE)" of the Tecnológico de Monterrey, included in national and international indexes. She served as Specialized Technical Advisor to the Governing Board of the National Institute for the Evaluation of Education (INEE). Visiting professor at the Mahatma Gandhi Institute of Education for Peace and Sustainable Development (MGIEP) Research Institute of the United Nations Educational, Scientific and Cultural Organization (UNESCO). Guest speaker at UNESCO's Mobile Learning Week - Paris Headquarters. Technical manager in projects of the National Council of Science and Technology (CONACyT) and the European Commission (Alpha Program). Member of the Mexican Council for Educational Research (COMIE), American Educational Research Association (AERA) and of the CONACyT Thematic Networks "Complexity, Science and Society", Convergence of knowledge for the benefit of society".