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RESEARCH ARTICLE

FORTAGONO: A Model for the Technological Mediation of the Teaching and Learning Processes

FRANCISCO LEPE-SALAZAR[1] AND TANIA CORTES-ALVAREZ[2]
[1]Ludolab, Colima 28000, Mexico
[2]Cognos+, Villa de Álvarez 28979, Mexico

Corresponding author: Francisco Lepe-Salazar (flepe@ludolab.org)

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ABSTRACT The role of technology in society is not passive. Little by little, technology has changed the way we communicate, express, and conduct ourselves in our daily lives. In the case of education, this has led to a transformation of the educational experience of teachers and students. However, not all are equally prepared to take advantage of it. To explore ways to contribute to the mitigation of this problem, inspired by participatory design techniques, we conducted a series of activities with teachers and students. After a qualitative analysis of the results, a model for the successful technological mediation of the teaching and learning processes emerged, which we call FORTAGONO. In this document we present this model and its evolution. We also discuss its benefits and limitations, and talk about our future work to develop a framework of use.

INDEX TERMS Digital education, digital transformation, education, learning, model, teaching, technological mediation.

I. INTRODUCTION

The integration of technology in different facets of society has brought about changes in the way in which products and services are chosen, acquired, consumed, and used. Partly, thanks to its ability to enhance the skills of users (i.e., to empower them). At a global level, this digitization of processes has led to great innovations and transformative changes in the political, social, cultural, and economic spheres [1], [2]. An example of this is digital banking, which in many countries has largely replaced in person transactions.

In the case of education, the integration of technology has resulted in a transformation in the way of teaching and learning [3]. However, despite the fact that the various stakeholders of education have adapted to changes over time, this has not always happened quickly or appropriately enough. The term stakeholder refers to the interest groups that must be taken into account in the strategic planning of an activity or project. The stakeholders of education include students, teachers, parents, managerial and administrative personnel, and the authorities of the ministry of education of the country or region [4].

Nowadays, students have the opportunity to learn various topics quickly, thanks to the wide variety of free resources at their disposal (e.g., video tutorials on YouTube, guides on WikiHow, research articles on Google Scholar), and effectively, thanks to platforms such as Coursera or Udemy which are interactive, customizable, and can be accessed at any time and from anywhere [5], [6]. That is why it may be suggested that, to be successful in the current digital age, education must meet requirements such as being self-sustaining, accessible, instantaneous, customizable, adaptable, collaborative, situational, and student-centered [7]. However, not all stakeholders of education (nor all technological tools) are prepared to make the qualitative and quantitative leap that would be required to meet these conditions.

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An example of the problems that may be experienced with this paradigm shift is what occurred recently, during the COVID-19 pandemic. To resume activities, many institutions were forced to open their doors to new technologies and to adopt different modalities of technological mediation of teaching and learning (e.g., online education, learning at scale). However, as some studies point out, results have not always been satisfactory.

A survey [8] applied to students and teachers who participated in online education during lockdowns, summarized some of the problems that many have encountered. Students mentioned the following problems: (1) discomfort or distaste for online learning, (2) lack of individual attention and socialization, (3) technical and connectivity problems, (4) lack of practical sessions, and (5) lack of access to equipment (computers, smartphones, Internet). On the other hand, teachers experienced problems such as: (1) having less student engagement, (2) requiring more time to prepare classes, and (3) having fewer ways to help students.

Moreover, the results of a survey applied to 438 university professors in Bangladesh who tried to adapt to online education during the COVID-19 pandemic shows similar areas for improvement [9]. Results were as follows: (1) approximately half of the teachers did not have previous experience with online education; (2) many had difficulties when carrying out practical activities, monitoring student learning, and applying evaluations; (3) the feedback they could give/obtain was insufficient; and (4) many had problems with their Internet connection.

Although some of the problems experienced by educational institutions when transitioning to different technological mediation modalities can be solved relatively easily (e.g., lack of technological training, connectivity problems), there are others whose solution implies a rethinking of the way of teaching and learning (e.g., carrying out practical sessions, monitoring the progress of the students).

In addition to that, the common or constant use of technologies to carry out activities, regardless of one's field of expertise or the domain of application of the task, implies the need to learn new concepts and develop new skills. This is the case as technology itself is constantly evolving. Thus, it may be suggested that there is a strong relationship between technology, skill development, and innovation [10].

Some of the characteristics of technology that favor the development of the teaching and learning processes are: (1) its ability to store and transmit information, since it allows one to manage large amounts of data simultaneously; (2) the dynamism of their contents, as it makes it possible to represent information in different ways; (3) transmediation, which refers to its ability to favor the dissemination of content in different formats and through different media; (4) interactivity, since it allows information to be manipulated in a multidirectional way; and (5) connectivity, because it allows collaborative and remote work [11]. However, there are various factors that can affect the experience that teachers and students have with technology (e.g., the level of training required to use it, its accessibility). Hence the importance of working on the development of specialized guidelines, models, methodologies, or frameworks of use.

Two research questions that guided our efforts throughout this project are: What is needed so that the teaching and learning processes can successfully take place through the use of technology? How should these processes be carried out?

To explore ways to address these questions, inspired by techniques for participatory design, we held a workshop with teachers from different backgrounds. During the sessions of the workshop, through various challenges and activities, teachers were invited to try different types of digital platforms and tools. This in order to help them reflect on possible strategies to mediate the teaching and learning processes. Next, we asked them to write a work log. With the data that was collected throughout the workshop, using techniques of grounded theory (e.g., textual analysis, axial and selective coding, etc.), we conducted a qualitative analysis [12], [13], [14].

With the categories that resulted from the previous analysis, which point to factors such as what to consider so that a teacher can select a proper digital tool to teach a class, we devised FORTAGONO: a model for the technological mediation of the processes of teaching and learning. A model is a scheme that seeks to explore, describe, order, explain, or predict the actions, processes, phenomena, states, events, results, or consequences that result from the interaction of interrelated variables and conditions [15].

To strengthen the usability and effectiveness of this new model, following recommendations found in [13], [14], and [15], a second workshop was held with new participants. As part of the activities of the second workshop, the initial version of the model was presented to the attendees. Subsequently, they were shown how to use it to plan one of their classes, and were later asked to test these classes with their students. With the information we collected during these sessions a qualitative analysis was conducted, and new categories emerged, which served to develop a second version of the model.

To continue strengthening FORTAGONO, we carried out an evaluation of its second iteration with students (through surveys) and teachers (through interviews) who had the opportunity to participate in online classes during the pandemic. As a result of this process, after a qualitative analysis of the information we collected, a third version of the model emerged.

In its current iteration, FORTAGONO is a model that allows one to teach technology-mediated classes regardless of the technological (e.g., lack of equipment, connectivity problems, lack of accessibility of resources), pedagogical (e.g., lack of freedom to decide the thematic content of the class), or human (e.g., lack of knowledge with regards to the type of students one will teach to) constrains one may face. In other words, it may be applied regardless of the location and context.

To explore how FORTAGONO relates to similar projects within the field of Computer Science (CS), we conducted a semi-exhaustive, systematic review of the literature. In this article we present our model and its evolution. In addition to that, we discuss its potential benefits and limitations. Lastly, we briefly talk about our future work aimed at developing a framework of use for the digital era.

In summary, the contributions of this project include the following: (1) an overview of relevant literature; (2) the results of a series of activities with students and teachers (e.g., workshops, interviews); (3) a new model for the technological mediation of the teaching and learning processes that contemplates work with all kinds of students (e.g., with special needs) and under various conditions/contexts; (4) a brief use guide and a sample scenario of the model; and (5) a revision of recent, related publications.

II. BACKGROUND

A. UNDERSTANDING THE DIFFERENCES THAT EXIST BETWEEN THE TEACHING AND LEARNING PROCESSES

Many conceive teaching and learning as two sides of the same coin. Nevertheless, even though they are related, there is empirical evidence that suggests that they are in fact interdependent processes [16]. Teaching is an interactive activity in which one person tries to transmit knowledge or skills to another, establishing a relationship of cooperation and work between them.

On the other hand, learning is a natural condition of the human being, which occurs habitually. It is a process that involves some kind of change: in what we remember, in our abilities, our attitudes, and/or our behaviors. Learning is not necessarily associated with morality, ethics, or any other type of value. Therefore, it is considered as different from formal learning. By formal learning we mean a deliberate and structured effort to learn, which does include values. It is therefore considered to be a planned, valuable, and desirable change in a person; a "*relatively stable modification of behavior patterns carried out in order to achieve an adaptation to the environment in which the organism or individual lives*" [17].

Taking these definitions into account, one may appreciate that these two phenomena, though related, are different. In other words, the existence of one does not necessarily imply that of the other. In this regard, Gvirtz and Palamidessi [17] state the following: *"teaching exists as an activity –and as a conceptualization– because learning occurs, but both processes are not necessarily identified"*. Therefore, it is not a cause-effect relationship that necessarily characterizes teaching and learning, although it must be said that the purpose of the former lies in the latter.

B. PEDAGOGICAL MEDIATION

Various educational paradigms and programs consider mediation as an inherent function of the teacher [18], [19]. For example, from a sociocultural point of view a teacher may be seen as a *"cultural agent that mediates sociocultural knowledge and the appropriation processes of the students through an adjustment of the pedagogical aid"* [20], and from a cognitive perspective a teacher may be regarded as an *"information organizer that builds cognitive bridges and acts as a promoter of thinking skills and strategies for meaningful learning"* [20].

The term pedagogical mediation is closely linked to the concept of learning environments. This is the case as the teacher is responsible for managing a set of factors that favor or hinder social interaction in a given physical or virtual space [21]. Therefore, for pedagogical mediation to take place a teacher must consider the physical, affective, and social aspects necessary to promote learning, regardless of where the class takes place.

Currently, teachers are seen as mediators of knowledge, as they facilitate access to information for their students, and continually challenge them to seek solutions to problems [22]. However, the role of the teacher is not limited to being an agent that transmits content to students. As suggested in [22] and [23], teachers are also able to design meaningful learning experiences if they consider the context and situations that their students experience in their planning.

In learning experiences, a mediating agent *"acts as a support and stands between learners and the environment to help them organize and develop their system of thought and thus facilitate the application of new intellectual instruments to the problems that arise"* [24].

Pedagogical mediation is also related to the Vygotskian concept of scaffolding. Scaffolding may be defined as a support system that is provided so that individuals can learn and solve problems, which will allow them to function in their zone of proximal development; that is, between what students already know or master and what they cannot yet learn without help [25]. In this way, the concept of pedagogical mediation can be paired with that of scaffolding, as both aim to support learners as they carry out the necessary actions to improve their abilities.

C. TECHNOLOGICAL MEDIATION

Human beings cannot be conceived independently of the world that surrounds them. This is the case as we are in permanent contact with our environment and context (i.e., immersed). Understanding human actions implies simultaneously considering the tools we use to carry them out. Therefore, technology is not a set of objects that are foreign or independent from us, but rather mediators that help us experience the world and be present in it in specific ways [4], [26].

Four types of relationships that arise from the human-technology-world tripartite interaction are: (1) embodiment or personification, which happens when we become "one" with the technology and experience the environment and context through it, an example of this is when using virtual reality glasses to play; (2) hermeneutics, in which technology provides us with a specific representation of the world, for example, when looking at the results of an MRI;

(3) alterity, in which the focus is on the technology itself, for example, when customizing options on a smartphone; and (4) background, in which technology seems to blend in with the scenery, for example when turning on the air conditioner in a room [27].

Verbeek [26] proposed two dimensions to simplify the understanding of technological mediation: (1) to act, linked to how technologies shape our actions; and (2) to perceive, related to how technologies help us to grasp reality and our surroundings differently. In summary, it can be said that technology provides us with new and significant ways of relating to the environment and our context, and vice versa. Hence, knowing better ways to understand and take advantage of this type of mediation is important.

D. TECHNOLOGICAL MEDIATION OF EDUCATION

In the case of education, technology plays the role of mediator of the relationships present in the didactic triangle made up of teachers, students, and content [11], [28]. Hence, as pointed out in [23], it acts as a catalyst for the construction of learning and knowledge. For teachers, this occurs when carrying out activities such as scheduling exercises, selecting materials, and coordinating the actions of students with tools (e.g., Google Docs). On the other hand, for students, this happens during the development of activities in digital environments (e.g., uploading a homework to Moodle), through which they can learn proactively. Therefore, as various experts suggest, technologies are capable of empowering both teachers and students, as they contribute to their development of a sense of agency and self-efficacy [29], [30].

According to [31], technology favors the following activities in education: (1) problem solving, through the manipulation of situations, which includes the evaluation of a problem, the creation of a problem space, the selection of goals, and the use of cognitive structures to achieve those goals; (2) exploratory learning, in which students are encouraged to explore and experiment on their own in pursuit of a goal; and (3) situated learning, in which the mental representation of a concept occurs in connection with the cultural, material, physical, and social context of a specific learning situation.

For teachers to take advantage of technology effectively, they must promote in their students the use of varied resources when carrying out activities (e.g., problem solving, reflection, physical experience, social learning) [30], [32], [33]. In relation to this point, there are a variety of approaches that seek to facilitate the development of educational activities with technology. Next, we present a summary of relevant exponents, which we took into account throughout this project.

M-learning (mobile learning) is the act of learning using personal electronic devices [34]. It is a form of distance education that allows users of mobile devices to study anywhere and at any time. The type of devices that can be used for this purpose include handheld computers, laptops, mobile phones, and tablets. It is often seen as ideal for informal learning. However, it does not easily lend itself to the learning of complex contents.

Blended (or hybrid) learning is a teaching method that integrates online technology with traditional classroom activities. Some of its benefits include greater flexibility, personalization, development of student autonomy, profitability, and greater satisfaction compared to normal classes [35]. Nevertheless, to be carried out successfully, both students and teachers must have a high level of technological skills, and sufficient technology at their disposal.

Flipped classroom is an instructional strategy in which content presentation occurs at home, while activities such as discussion, problem solving, etc., take place during class [36]. For its execution, it requires the use of digital platforms that can be consulted by students. Among its benefits is greater participation and satisfaction on the part of the students. Some of its limitations include the need for more time to plan the courses, and the need for more time for students to learn the theoretical content on their own.

Video games offer interactive, digital environments capable of evoking a wide range of experiences. By playing a video game, users may be able to learn new skills, knowledge, ideas, attitudes, or behaviors that challenge them to think, explore, respond, and even create, just like in constructivist learning environments [37]. Hence, game-based learning (GBL) has increased in popularity in recent years. GBL has two main aspects: (1) the use of games developed for the purpose of entertainment that may have an educational value (e.g., Civilization, SIMS); and (2) game creation. Whether just playing a game or creating it, GBL favors a flexible, constructivist approach to learning. A limitation of GBL is that not every video game title lends itself to being used in a class. On the other hand, the video game development process is complex and requires a high level of technological skills on the part of the people involved.

Video games that are designed for purposes that go beyond fun are known as serious games [38], [39]. Serious games that seek to contribute to the learning of the players are referred to as educational games (EduGames) [40]. To achieve their goal, EduGames follow learning theories or approaches such as problem-based learning or deep learning [16], [41]. There is a wide variety of commercially available EduGames (both in physical and digital format) that can be used as support material for a class. Unfortunately, as with commercial video games, one of their main disadvantages is that there are no titles available for certain topics.

Gamification refers to the use of game elements in contexts other than games [42]. It is commonly implemented with the intention of positively affecting the attitude, cognitive skills, emotional state, motivation, performance, productivity and understanding of the participants [43], [44], [45], [46], [47], [48]. In the case of education, gamification has been used successfully to contribute to the learning of topics that students may consider to be boring or not very entertaining. However, some of its drawbacks include the difficulty of gamifying a class, and the dislike of some students for games in general.

ADDIE is a framework for instructional design that consists of five phases: (1) analysis, which distinguishes between what students already know and what they need to know by the end of the course; (2) design, in which the objectives are identified and the instructional strategies, means, and methods to be used to achieve the objectives are prepared; (3) development, in which a product is prototyped, created, and tested; (4) implementation, in which the product is analyzed, redesigned, and improved; and (5) evaluation, in which it is determined if the problem has been solved, if the objectives have been met, and if changes are necessary [49]. Despite being used by various institutions to promote the integration of technologies in education, it has some disadvantages. These include: (1) lack of flexibility to adapt to change (e.g., changes in school policies, budget reductions, changes in participants), (2) high degree of complexity for the carrying out each phase, and (3) rigor and lack of room for creativity.

Hackathon is a term used to refer to short-term events that promote competition among participants and problem solving with technology [50]. They are regarded as pedagogical strategies since they allow students to be offered an informal learning environment to practice the adoption of skills typical of technological development, such as understanding problems, eliciting requirements, and designing technological solutions, as well as to work in groups and to develop social skills such as communication, negotiation, and conflict resolution. Among its limitations, the limited time available to work and the fact that the formation of teams is not necessarily done based on the ability of the participants stand out.

The UNESCO ICT Competency Framework for Teachers states that, in addition to knowing how to use technology, teachers must make use of it to help turn their students into collaborative, creative, problem-solving, innovative, and committed members of society [51]. To this end, UNESCO suggests: (1) the preparation of activities applicable inside and outside of the classroom, that is, that go beyond merely school subjects; and (2) the carrying out of activities that promote competencies inherent to knowledge society (e.g., communication, collaboration, experimentation, critical reflection). The foregoing through the integration of tools and digital content. Although this framework addresses some aspects related to technology-enhanced teaching, it does not delve into the types of activities that may be conducted or the ways of evaluating results.

The 70:20:10 framework promotes the strategic division of time during the learning process. Said partition is proposed as follows: (1) 70% must be used to practice using technological tools, as well as to have experiences in real scenarios (or close to reality, through simulation software); (2) 20% to collaborate with third parties; and (3) 10% to listen to class or read texts [52]. This framework is commonly used in face-to-face courses and workshops, the purpose of which is to teach technical or practical skills. However, it does not lend itself to the development of online activities. In addition to that, it does not allow working with students who do not have a minimum of equipment or skills.

Carrington [53] devised the wheel of pedagogy, a taxonomy for the selection of technological tools linked to different teaching goals. The way this taxonomy works is as follows. First, the teacher must locate in the inner circles the educational goal they want to achieve. Afterwards, the teacher will need to move to the next circle to choose one of the recommended tools. Although this taxonomy has received updates (the most recent one from 2015), there are new and better applications that allow one to achieve similar goals. On the other hand, to be properly used, it is necessary for the teacher to master several of the tools recommended for each educational goal. Lastly, many of the tools it recommends are not free, which represents an entry barrier for those who do not have the necessary resources to acquire them.

The Florida Center for Instructional Technology (FCIT) at the University of South Florida created the Technology Integration Matrix (TIM), a framework to describe and focus the use of technology to enhance learning [54]. TIM consists of two categories: (1) levels of technology integration and (2) characteristics of the learning environment. The levels of technology integration that it considers are: (1) entry, (2) adoption, (3) adaptation, (4) infusion, and (5) transformation. The characteristics of the learning environment it addresses are: (1) active, (2) collaborative, (3) constructive, (4) authentic, and (5) goal oriented. Unlike other frameworks and models, to be utilized, TIM requires that both teachers and students have an advanced level of functional and technological literacy. For this reason, its implementation may be difficult at basic educational levels, or in places where not all participants have the necessary skills.

Petty [55] developed the PAR (present, apply and review) model, which is based on constructivism. On his website (http://geoffpetty.com/), the author presents the planning of various activities for hands-on learning. Nevertheless, since this model was not explicitly designed for the development of technology-mediated activities, it does not necessarily lend itself to them.

Salmon [2] presented E-tivities, a model whose objective is to facilitate the planning of online activities. However, its focus is limited to this type of technology-mediated education (i.e., online). In addition to that, the types of technological devices that the model contemplates are limited (e.g., interventions available only for desktop computers with Internet access).

Lastly, there are some models that seek to contribute to the integration of technologies in schools, illustrating the adoption process that these can go through when implemented in an institution. Such is the case of ITIC-PD [23], and the model presented in [56]. Unlike the approaches that were mentioned previously, these do not necessarily contribute to the planning of the instructional design of a class. Therefore, they are not directly linked to the classroom or pedagogical exercise of the teacher.

In summary, the frameworks, methodologies, and models mentioned above have the following limitations: (1) not all of them lend themselves to the development of face-to-face activities, (2) they cannot be used by students or teachers who do not have a minimum of equipment or skills, (3) most are linked to a specific type of technology or mediation modality, (4) many are not directly linked to the classroom activities of the teacher, and (5) many lack the flexibility to adapt to changes.

To contribute to the advancement of the area, we worked on the development of a new approach that: (1) allowed for the development of face-to-face, blended, online, and distance education, among others; (2) contemplated all types of equipment and the skills of those involved (i.e., teachers and students); (3) lent itself to its implementation with all kinds of technology and under all kinds of mediation modalities; (4) whose use was closely linked to the classroom activities of the teacher; and (5) which was malleable and allowed for modifications to accommodate changes, when/if necessary.

1) AVAILABLE TECHNOLOGICAL RESOURCES

People process information in different ways (i.e., under different modalities). Some of the better known information processing modalities include visual, auditory, and kinesthetic. To fully take advantage of them, it is recommended to follow different approaches [57]. In the case of education, for students who tend to process visual information better, resources such as presentations, demonstrations, films, diagrams, photographs, texts, graphics, etc. can be used. In the case of students who process auditory stimuli better, they can benefit from receiving oral instruction, reading aloud, word associations, group discussions, music, video with voice instructions, etc. For those who are more kinesthetic there are exercises such as problem solving, role playing, making lists, analysis, etc.

There are a series of technological resources that can be used for learning and teaching under different information processing modalities. These include: agents, animations, Arduino, artificial intelligence, audio recordings, audio samples, augmented reality, automated feedback systems, big data analytics, blogs, chat rooms, cloud computing services (e.g., Google Cloud, Microsoft Azure), computer brain interfaces, computer software, computer vision software, crowdsourcing, dashboards, devices (e.g., desktop computer, interactive whiteboard, laptop, smartphone, tablet, touch panel), design tools (e.g., Adobe Illustrator, Adobe Photoshop, Corel Draw, Draw.io), digital libraries (e.g., Elsevier, ACM Digital Library, IEEE Xplore, Sciencedirect, Google Scholar), DropBox, e-books, FabLabs, forums, game-based tutors, gamified platforms, GitHub, GitLab, Google Cloud Services (e.g., Classroom, Docs, Drive, Forms, Sheets, Slides), intelligent tutoring systems, interactive platforms, interactive tutorials, learning analytics, learning management systems (e.g., Blackboard, Canva, Moodle, Yeira), mobile apps, MOOCs (e.g., edX, Coursera, Khan Academy), multimedia (e.g., animation, audio, images, graphics, videos, sound effects), online quizzes, platforms, podcasts, practice test websites, prototyping tools (e.g., Adobe XD, AppInventor, AppyBuilder, Bubble, Figma, InVision, Proto.io, Scratch, Thunkable), Raspberry Pi, recommendation systems, serious games, simulations, story-based interactive learning environments, Stack Overflow, step-by-step guides, social media (e.g., Facebook, Instagram, Line, Twitter), videoconferencing services (e.g., Microsoft Teams, Skype, Zoom), video games, virtual classrooms, virtual labs, virtual reality, vlogs, web browsers, web pages, Wikipedia, and YouTube [37], [50], [58], [59], [60], [61], [62], [63], [64], [65], [66], [67], [68], [69], [70], [71], [72], [73], [74], [75], [76], [77], [78], [79], [80], [81], [82], [83], [84], [85].

2) BENEFITS AND LIMITATIONS

Among the benefits of working with technology in education, for teaching or learning, the following stand out: (1) the ability to personalize learning experiences; (2) the opportunity to provide valuable experiences; (3) the possibility of using new and innovative tools; (4) the potential to provide alternative forms of learning; (5) the ability to establish among students the habit of preparing adequately for a class; (6) the opportunity to promote cooperative learning; (7) the possibility of promoting values (e.g., leadership) among students; (8) the potential to motivate students (e.g., stimulating their intellect, providing rewards); (9) the ability to plan flexible strategies; (10) the opportunity to prepare activities that foster the intellectual development of students; (11) the ability to positively affect the attitude of students and teachers; (12) the ability to improve teacher-student and student-to-student communication; (13) the opportunity to develop individual and group skills; (14) the possibility of preparing exercises to improve students' metacognition; (15) the ability to connect students with real-world problems and scenarios; (16) the ability to present problems and concepts from different perspectives; and (17) the possibility of promoting information comprehension and retention [37], [50], [60], [64], [68], [77], [86], [87], [88].

On the other hand, among the limitations of using technology in education, the following stand out: (1) the type and variety of evaluation that can be carried out may be limited or limiting (e.g., use of surveys to assess acceptance); (2) technology solutions may not be available or accessible to everyone; (3) lack of digital skills (of students or teachers) can affect performance; (4) the time necessary to plan a class or course may be more than without using technology; (5) not all educational institutions can or want to support the development of technology-mediated courses; (6) there may be apathy towards technology on the part of students or teachers; (7) some subjects or topics cannot be easily taught/learned through technology; (8) some may misuse technology (e.g., use it as a distraction); (9) some can fall into one-size-fits-all approaches, which can be limited and limiting; (10) the available materials may not be of good quality; (11) if

face-to-face and online activities are carried out, there may be disconnection or discontinuity between what is done at home and in the classroom; (12) the level of reading ability required to consume content may be high; and (13) the use of certain digital resources can be distracting for some students [41], [59], [68], [74], [78], [87], [89], [90], [91].

E. STRATEGIES FOLLOWED DURING THE PANDEMIC

During the pandemic, to avoid interrupting the students' learning process, different strategies were adopted worldwide. Next we present a summary of relevant examples we took into account for our project.

In the United States of America, different strategies for remote learning were followed, which contemplated the use of software for videoconferencing and audiovisual resources (e.g., videos, texts, audio, etc.) [92]. It is worth mentioning that, to guarantee student access to Internet, a wireless connectivity plan was launched by the Department of Education [93]. Some of the activities carried out by teachers during the pandemic included: (1) maintaining communication with students and parents, (2) preparing materials for student consumption, and (3) preparing different learning opportunities for students. [94], [95].

In the United Kingdom, a plan for remote teaching and learning was established. This plan contemplated the active participation of parents [96]. Teachers and students were required to conduct their classes online through videoconferencing software [97], [98]. Among the devices most used by students were laptops, desktop computers, and smartphones.

In Japan, various online education approaches were devised [99]. For their execution, different tools were utilized, including Moodle or Slack for teaching, and Microsoft Teams to communicate with students [100]. In addition to that, the Ministry of Education prepared support materials to teach classes online [101].

In Brazil, the strategy they adopted to give continuity to education was to allow teachers and students to make use of the technological resources at their disposal [102]. An example of the activities that teachers carried out was creating groups through messaging software (e.g., WhatsApp) to send activities to students, and to collect the classwork for evaluation purposes [103].

Lastly, in Mexico the plan followed during the pandemic was titled the ''new Mexican school for digital culture'' [104]. Said plan sought to promote, among other things, civic and ethical coexistence, as well as the physical activation of students [105]. Among the activities contemplated by this plan, the following stand out: (1) ask teachers to follow the instructions prepared by the Ministry of Education, (2) ask students to watch the material provided by the Ministry of Education on television, and (3) ask teachers to evaluate the work done by students [106].

In summary, a majority of the countries we studied sought to make use of the technological resources at their disposal, some established plans for remote education, and just one (i.e., USA) established a plan to increase Internet access for students.

Inspired by these findings, we set out to create a new approach whose operation did not directly depend on device accessibility, and which was capable of adapting to different pedagogical strategies for its execution.

III. CONSTRUCTING THE MODEL

To explore ways to contribute to the successful technological mediation of the teaching and learning processes, inspired by techniques for participatory design (e.g., workshops, mapping, prompted reflection, experimenting with tools, developing scenarios) [107], [108], we carried out various activities that contributed to the creation of our model FORTAGONO.

A. FIRST WORKSHOP

From February to March 2020, we held a four-session workshop (six hours each) with eight participants who teach in public and private institutions, and at different levels including kindergarten, elementary school, middle school, high school, and university. Regarding the participants, 6 of them were men and 2 women, with an average age of 34 years. It is worth mentioning that this workshop took place weeks before the suspension of face-to-face activities due to the COVID-19 pandemic. Figure 1 shows some photographs taken during these sessions.

The activities that took place on each session were the following: (1) presentation of technological tools (different each session), (2) teaching planning of a class under a modality of technological mediation (different each session), (3) development of an instructional design, (4) selection of materials, (5) presentation of tools and platforms they could use to set up their class (e.g., Google Classroom, Yeira, Schoolify, etc.), (6) preparation of a sample class under the specific mediation modality, (7) presentation of the sample class (10 minutes maximum per participant), and (8) filling in their work log. It is worth mentioning that, to reduce their workload, teachers were allowed to finish their work log entry during the week. Additionally, we followed up their progress by email.

Some of the aspects that participants were asked to consider to develop the planning of their sample class were: (1) a learning theory that could best contribute to the achievement of objectives, (2) an educational goal based on Bloom's Taxonomy, (3) technological products and services available to them and their students, (4) information they had regarding the information consumption habits of their students, and (5) possible divergences among their students in terms of the way they think, act, approach problems, and set goals.

Teachers were encouraged to try the sample classes during the week. We did this so that they could have a chance to reflect on the scope and limitations of each technological mediation modality. Lastly, they were asked to write brief reports on technological and educational trends related to each mediation modality we covered (e.g., crowdsourcing in the case of learning at scale).

With the information that was collected during the sessions, a qualitative analysis was carried out using grounded theory techniques such as textual analysis, and axial and selective coding [12], [13]. Next we present the categories that emerged as a result.

1) CENTRALITY OF THE EDUCATIONAL GOAL

For workshop participants, the selection process of the educational goal is central to student learning. *"Student performance depends on how efficient they are at learning, thus, the teacher's goals must be correctly aligned to the objectives of the study program and supported by materials that contribute to student learning"*, highlighted one of them in his log. Another participant observed the following: *"one must take into account that educational goals are ways to achieve learning... they are meant to help learning, the acquisition or building of knowledge on one or several topics through their implementation"*.

According to research carried out by Guzdial [109], there are three perspectives that a teacher can have when teaching: (1) guided learning, (2) transmission of content, and (3) personal development. In the first, guided learning, teachers take on the role of experts who show students what to do and how to act, and provide them with opportunities to practice what they've learned. In the second, content transmission, the teacher provides the knowledge and ensures that students are prepared to cover subsequent courses. In the third, personal development, teachers evaluate student performance and determine what they need to progress individually; in addition, they encourage values such as peer work and proactive learning.

Depending on which perspective for teaching a teacher chooses, he or she will be able to define the educational goal. To facilitate this process, a teacher can make use of Bloom's Taxonomy, a framework that classifies the educational goals or objectives that can be had in a lesson or learning unit. In its original version, this framework consisted of six main categories: (1) knowledge, (2) understanding, (3) application, (4) analysis, (5) synthesis, and (6) evaluation. However, in 2000, a group of psychologists and educators published an updated version which, unlike its predecessor, seeks to divert attention from the static notion of goals and objectives in favor of a more dynamic conception [110]. Table 1 below shows a summary of the 2.0 version of Bloom's Taxonomy.

TABLE 1. Summary of revised version of bloom's taxonomy.

Categories	Subcategories
Remember	recognizing recalling
Understand	interpreting exemplifying classifying summarizing inferring comparing explaining
Apply	executing implementing
Analyze	differentiating organizing attributing
Evaluate	checking critiquing
Create	generating planning producing

This table presents a summary of the explanation of the new Bloom's Taxonomy found in [110].

2) ADAPTING TO CHANGES IN HABITS IN THE CONSUMPTION OF INFORMATION

One participant, reflecting on the future of information consumption through digital media, wrote the following: *"(In the future) technology will serve not only to improve the learning process of those students who decide to learn, to learn at anytime and anywhere, but also of those who decide to attend a classroom to continue their studies"*. Another participant highlighted the following regarding the way students use technology: *"Students nowadays, because they are Digital Natives, have a different view of the world based on their use of technology. They learn in different ways and divide their attention between different tools at the same time. They are multitaskers"*. On the other hand, regarding the type of content that should be included in classes mediated by technology, one participant mentioned the following: *"The content should be varied, appropriate to the needs of the students and adapted to the possible characteristics that the students might have... as well as to the various channels of communication there are, and their learning speed, interests, etc."*.

Over the years, the type of information we share, the way we do it (i.e., communication itself), and the medium through which we do it have changed. While in the past it was necessary to wait for months to communicate with someone in another country (e.g., after sending a letter or telegram), today this can be done immediately via email or mobile short message service (SMS).

Information has changed in terms of quantity, extent, variety, quality, and frequency of sharing. On the other hand, communication has changed in terms of the senses involved in it. For example, to see a drawing or read a text we only need our sight, however, if we wanted to play a virtual reality game and communicate with a character in it we would need our hearing, sight, and touch. The means of communication have evolved from pictographs to calligraphy, multimedia, and more recently, transmedia. The term transmedia refers to works where the same narrative appears in different media (i.e., intertextuality). For content to be considered transmedia, it must: (1) be divided into parts or by-products, (2) be presented through different channels or media, (3) provide a

unified consumer experience, (4) avoid redundancy between parts or by-products, and (5) have an order or consumption scheme.

According to workshop participants, this is relevant for the teaching and learning processes since new students and teachers are not satisfied with consuming static content. In summary, younger generations are looking for content that is accessible, interactive, reusable, enjoyable, storable, easily consumed, fun, cross-platform, and multisensory, among others. An example of this new trend may be appreciated in the rise of short-length media platforms such as TikTok.

3) DIFFERENCES AMONG STUDENTS

A workshop participant, when writing about the characteristics of the students, highlighted the following: *"In order for teachers to be able to bring about change in their students not only in terms of knowledge, but also skills, it is necessary for them to take into account the interests of the students, their way of thinking, and learning styles"*. In this regard, other participant mentioned the following: *"The activities we have at class must allow for the acquisition of the necessary skills, according to the abilities and needs of each student"*.

Although students in a class may share characteristics such as age, socioeconomic status, ethnic group, language, and city they live in, among others, it should be noted that they commonly differ in their: (1) way of thinking, (2) way of acting, (3) way of approaching or reacting to problems, and (4) way of setting objectives and goals. It should be clarified that by way of thinking we refer to how students approach and solve problems with their minds, not necessarily to their ideologies or personal preferences. Given the complexity of these issues, teachers may seek the support of experts in areas such as psychology, among others, to address them.

The theory of multiple intelligences [111] emphasizes that an individual's ability to think is limited by the type of mental abilities that are most developed. In the original list compiled by the author, the following intelligences were highlighted: (1) linguistic, (2) logical-mathematical, (3) spatial, (4) musical, (5) bodily-kinesthetic, (6) intrapersonal, (7) interpersonal, and (8) naturalistic. That is why, to teach students with different ways of thinking, it is recommended to provide thematic content in various formats (e.g., audio, video, text, diagrams, etc.).

An attitude is a type of response (positive or negative) towards a stimulus, person, situation, or object [112]. It can be learned, relative, temporary, or permanent. Attitudes are closely linked to a person's emotions, memories, and beliefs [112]. That is why they tend to affect the way we conduct ourselves. For example, having a negative experience in specific situations (e.g., presenting in public) can lead us to have a bad attitude about it when we find ourselves having to repeat it again. As suggested in [113], it is necessary for teachers to consider in their planning the type of content, the form, and the moments to present them, to avoid adverse reactions in students.

When tackling a problem, no matter what or how much we know about it, we tend to fall back on strategies that have worked for us in the past. According to [114], the main difference between an expert and a neophyte lies in how correct their assumptions are about how to solve the problem, and how long it will take them to reach a solution. For this reason, it is important that teachers, before defining the difficulty and type of activities for a class, contemplate the previous knowledge and skills of their students, and their connection to the new topics to be covered.

According to the theory of goal setting and skill performance [115], there are two determinants of an individual's behavior and success: their values and their intentions (i.e., goals). By value we mean the significance, validity, or importance given to a stimulus, person, situation, or object. An intention or goal can be defined as what a person is consciously trying to do. Locke and Latham [115] posit that: (1) values create in us the desire to do things consistent with them; and (2) goals channel our attention and actions, and motivate us to make a bigger effort. That is why, to motivate students to meet the objectives of a class, the teacher must align them with their personal values and goals.

4) IMPACT OF THE TECHNOLOGICAL MEDIATION MODALITY IN THE TEACHING AND LEARNING PROCESSES

When talking about how the role of the teacher has changed as a result of the integration of technologies, a participant wrote the following: *"In the past the teacher's job was to be in the classroom, presenting and explaining, transmitting knowledge. However, currently, the teacher's job goes deeper in terms of planning, to design the spaces, means, strategies, techniques, and models needed to ensure that students learn and develop skills"*. One of the participants described teachers of the 21st Century as: "*people prepared in the field of technology, who must acquire abilities and skills to be able to guide students. They must be aware of the various digital tools and teaching modalities available, so that learning takes place in the digital realm. In addition to that, within their practice, they must have a broad vision of the various contexts and characteristics of the students"*.

Another participant mentioned the following: *"The teacher has the responsibility of obtaining the technological acumen that will allow him or her to plan the right activities to meet the specific needs of students, and to consolidate meaningful learning experiences"*. *"Students expect digital education to be attractive, to improve their knowledge, to be eye-catching, and interesting"*, answered a teacher when asked about the expectations that students have when studying through technological means.

To remain competitive in an increasingly saturated market, educational institutions (both public and private) must provide enriched learning environments [30], [116]. An enriched learning environment is understood as those spaces that promote, among other things, the free exchange of knowledge, development of skills, and mastery of concepts. One

way to achieve this goal is by using specialized hardware and software. However, due to innovation and technological development, both hardware and software are in a constant process of updating and changing. This has led to the emergence of different modalities of technological mediation of teaching and learning processes, among which the following stand out: (1) distance education, (2) online education, (3) learning at scale, and (4) digital education.

Distance education is a mediation modality, which does not require or contemplate that students physically attend a classroom. Its way of operating is as follows: (1) students receive the study material directly; (2) students consult said material on their own, following a study guide; and (3) students accredit their learning by answering pre-established evaluation formats.

The first course taught under this modality took place in Boston, Massachusetts in 1728 [117]. On that occasion, to get the materials to the students, teachers used the American postal service. It was not until the early 1990s that technology began to be commonly utilized in this type of mediation modality. The foregoing thanks to the popularization of multimedia and storage formats such as the CD. Distance education *"is a product of the organization of activities and pedagogical resources that the student uses, autonomously and following his or her own wishes, without being forced to submit to spatial-temporal constraints nor to the authority relations of traditional education"* [118].

Online education is a mediation modality characterized by the interaction between teachers and students, through specialized hardware and software. It is considered that this modality was born from the massification of the Internet at the end of the 1990s. Although some authors consider it to be an evolution of distance education, others believe that the nature of online education is different. This given that its objective lies in the constant interaction and cooperation between the members of the didactic triangle: teachers-students-content [119]. In other words, online education differs from the previous one in that it is developed through technological tools conducive to dialogue and activities between two or more people. A type of technology that emerged from this modality are learning management systems (LMS). An LMS is software installed on a web server that allows users to distribute and manage activities. Lessons or courses that take place in an LMS usually contain resources such as videos, audios, forums, boards, and wikis, among others.

Learning at scale arose from the need to provide services to large numbers of students synchronously or asynchronously. This is possible thanks to the ability of technology to amplify human effort [120]. Learning at scale has the following characteristics: (1) it is accessible to large audiences from anywhere in the world; (2) it may provide free and open content; (3) its structure is designed to promote autonomous learning; (4) it supports multimedia files; (5) it allows for interactivity and collaboration (synchronous or asynchronous) between participants; and (6) activities take place (on their entirety) online.

FIGURE 1. Photographs of participants of the first workshop.

The type of technology that emerged from this modality are massive open online courses (MOOC) and nano-massive open online courses (NOOC). MOOCs and NOOCs take place in online educational platforms that are supported by experts and computer algorithms to track student progress. Unlike the previous modalities, in learning at scale, students outline their personal objectives and directly manage their progress trajectory. This is the case as there are students who seek to learn a particular subject, others who wish to obtain a certificate for specific skills, and those who wish to obtain a degree, among others.

Lastly, digital education is a mediation modality that is still in development. Some of its core elements are: (1) interaction and collaboration between actors; (2) teaching and learning processes adjustable to the preferences of teachers and students; (3) diversification of the media that is utilized and the type of content that is presented; (4) content accessibility (for all types of audiences); (5) expert support and computer algorithms for tracking student progress; and (6) development of activities in digital ecosystems.

Digital ecosystems are spaces without geographical or temporal restrictions (i.e., ubiquitous), in which all kinds of components are distributed on different platforms (i.e., multimodal and multiplatform), and in which stakeholders interact to carry out their activities (i.e., multi-user). It should be noted that the concept of digital ecosystems is still under construction, as no single tool or service meets all the conditions specified previously. Nevertheless, next generation MOOCs and NOOCs are expected to be designed following these precepts [121].

Table 2 below presents a matrix with characteristics that, according to the workshop participants, should be considered to define the type of technological mediation modality that should be chosen for a class or course.

B. FIRST VERSION OF THE MODEL

After considering the categories and insights that resulted from the first workshop, a model of the most important factors one must take into account to successfully mediate the teaching and learning processes making use of technology emerged (fig. 2). The name we gave to this model is FORTAGONO, which was derived from the words 'fortaleza' (fortitude or stronghold in Spanish) and 'polígono' (polygon in Spanish). This was the case as we wanted to highlight the need to consider different, related aspects for the educational experience of students and teachers to be good. A summary of the model is presented next.

The first step teachers must take is to define the unit of learning of the session. Subsequently, they must select

TABLE 2. Matrix of technological mediation modalities of the teaching and learning processes.

Characteristics	Mediation modality			
	Distance education	Online education	Learning at scale	Digital education
Delivery	In-person / Face-to-face Blended	In-person / Face-to-face Blended Online	Online	Online
Role of the teacher	Creator of tutorials and guides	Tutor Facilitator	Expert Guide	Expert Activity orchestrator
Role of the student	Passive receiver	Passive receiver	Proactive participant	Protagonist of their own learning
Type of teaching	Transmission of thematic content	Guided learning Transmission of thematic content	Guided learning Transmission of thematic content	Guided learning Transmission of thematic content Personal development
Type of learning	Autonomous	Guided	Autonomous Self-managed Self-directed	Autonomous Self-managed Self-directed Autodidact
Related learning theory	Behaviorism	Behaviorism Cognitivism	Cognitivism Constructivism	Cognitivism Constructivism
Means to communicate	-	E-mail Forums Chat Videoconferencing Social networks Instant messaging	E-mail Videoconferencing Chat	E-mail Videoconferencing Chat
Communication modality	-	Synchronous Asynchronous	Synchronous Asynchronous	Synchronous Asynchronous
Temporality	Linked to a school calendar	Linked to a school calendar	Open	Open
Used technology	CD Multimedia Repositories	LMS Platform Multimedia Repositories Forms Video Games	MOOC NOOC Multimedia Repositories Forms Video Games	Digital ecosystem Artificial intelligence Big data Cloud Transmedia
Method of evaluating	Exams	Exams Individual and group activities	Percentage of curricular progress Performance in evaluations and activities	Units or modules completed Performance in evaluations and activities

the educational goal to be achieved in said session, preferably taking advantage of the updated version of Bloom's Taxonomy [110]. It should be noted that, the decision of what learning theory and teaching style/method to follow (e.g., project-based, problem-based, etc.) is up to the teacher. After that, teachers must assess the following aspects of their students: (1) information consumption habits; and (2) ways of thinking, acting, approaching problems, and setting goals.

With this information at hand, they can begin to prepare the material for the session. This either through the creation of new resources, or by curating existing content. After that, teachers must define an order of consumption of the materials following the recommendations for transmedia narrative. Next, they should review the features of the technology available to both them and their students. This to verify that it is accessible to all (i.e., that everyone can use it).

Once teachers have a clear idea about the factors mentioned above, they can choose the technological mediation modality that best suits their situation by using the matrix of technological mediation modalities (table 2). Lastly, teachers can plan the flow of the session's activities.

C. SECOND WORKSHOP

One way to improve the usability and effectiveness of a model is to test it with a different group of individuals [15]. The term usability is commonly used to refer to the ease with which a person can make use of a service or product to achieve a goal or an objective. Some of the most studied aspects of usability are ease of use, satisfaction, and suitability [122],

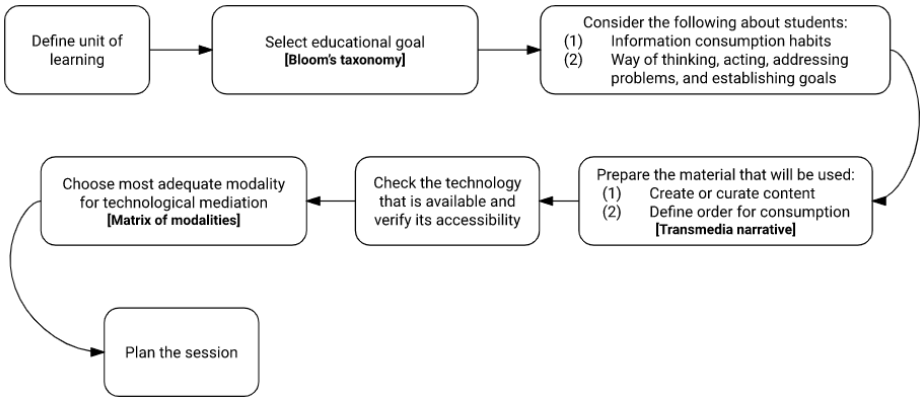

FIGURE 2. Graphic representation of the first version of the model.

FIGURE 3. Screen capture of a session of the second workshop.

[123], [124]. Effectiveness is a term used to refer to the balance between two factors: efficacy and efficiency [125].

Efficacy refers to the ability a person has to achieve a goal. Efficiency is the ability to achieve a goal using few resources, or in a short time. Therefore, a model can be considered to be usable if it is easy to use, satisfies users, and suits their needs; and it is effective if it is able to achieve its goal using the least amount of resources possible.

To improve our initial model based on the aforementioned criteria (i.e., usability and effectiveness), from November to December 2020, a second four-session workshop (3 hours each) was held with a new group of teachers who came from public and private institutions, who teach at different levels including elementary school, high school, and university. Ten teachers participated, 3 men and 7 women, with an average age of 38 years. Given the restrictions imposed by the local government due to the COVID-19 pandemic, the activities of this workshop took place remotely through platforms such as Google Meet (Fig. 3).

During the first session, the first iteration of FORTAGONO was presented to participants. Next, we taught them how to use it to plan a session mediated by technology. The activities that were conducted on every session were the following: (1) presentation of a technological mediation modality (different on each session), (2) teaching planning of a session under said modality using the model, (3) preparation of a sample class following the model, (4) presentation of the sample class, and (5) filling out a work log. Like in the previous workshop, participants were provided individual follow-up via email. Additionally, they were asked to implement the sample class with their students during the week. The information collected during the sessions of the second workshop was subjected to a qualitative analysis. Next, we present the categories that emerged as a result.

1) BALANCING PEDAGOGY AND TECHNOLOGY

As part of the activities, teachers were invited to give their opinion regarding the relationship that should exist between pedagogical and technological mediation, and how it could affect the planning of a session mediated by technology. In this regard, a teacher said the following: *"There has to be congruence between the two so that student learning can be achieved"*. Another of the participants suggested that since *"technological mediation of education is born from the relationship that exists between the teacher and ICT (information and communication technologies), to get the most out of this relationship, it should be used with limits and in a guided way"*.

One of the teachers believed that a balance should be struck between the two: "*I conceive pedagogical mediation as the conscious and intentional accompaniment that a teacher provides to all students in the search for concrete learning… technology is not an end in itself but the means to achieve specific learning"*. As a result of these observations, in collaboration with the participants, a list of considerations to take into account before planning a technology-mediated session was drawn up (Table 3).

Regarding the aspect of 'Methodology' (Table 3), there are a variety of approaches that can be followed to ensure that the activities of a session are carried out satisfactorily. These include blended learning, flipped classroom, and gamification, among others.

2) COMMUNICATING EFFECTIVELY WITH STUDENTS

On one occasion, participants were asked to mention challenges they had faced when teaching technology-mediated classes. Most responses had one thing in common: difficulties communicating with students. The types of difficulties mentioned varied, from problems adapting to the use of different digital tools, to questioning the value of the communication that takes place through them.

TABLE 3. Considerations for the instructional design of a technology-mediated session.

Aspects	Considerations
Technological availability	What devices does the teacher have? What devices do students have? Are these devices accessible to all types of users?
Mediation modality	Based on the technology available to the teacher and students, which technology mediation modality would be best to follow?
Activities for the session(s)	In what sequence or order will the activities of the session be carried out?
Theoretical framework	What information should students know in order to carry out the activities? What theoretical support do they need?
Methodology	What steps must be taken for the activities to be carried out satisfactorily?
Limitations	What problems will the students face in carrying out the activities? How can they deal with them?
Evaluation	How can one know if the results of the activity were positive? What evaluation metrics can one use?
Desired result	What is the ideal result of the activities? What can one hope to achieve?
Reflection	What can be highlighted so that the students understand the end goal of the activities?

A workshop participant expressed that this new way of teaching meant for everyone *"A change in the conceptions we had about education. To get ahead of this challenge, it is necessary to pay attention to the emerging new ways of intervening and transmitting knowledge"*. Another teacher highlighted that the most difficult thing for her had been to maintain the dynamism and motivation of her students. In this regard, she expressed the following: *"As teachers we must create environments for the interaction with the students, which lead to fulfilling the objectives of the subjects to be taught. These new environments can emerge unconventionally from new modes of perception and language, new narratives, writings and sensibilities"*.

Another teacher highlighted a problem that, in his opinion, makes it difficult to communicate with students. He used the term *"fallacy of virtual dialogue"* to refer to communication that occurs through digital media. In his opinion, *"as there is no way to verify how the other person reacts to what has been said, part of the richness of the communication process can be lost"*.

Communication is an essential ingredient of human relationships. For people to have quality communicative interactions, they must establish bonds of trust (called rapport) with others. For rapport to exist between two people, three elements are needed: congruence, empathy, and acceptance of the other [39]. However, as highlighted in [126], for this link to be truly effective, it is necessary for both parties to be clear about the following: (1) self-concept; (2) self-esteem; (3) meaning of life (referred to by some authors as raison d'être, or reason for being); and (4) how to achieve a state of wellness.

The various internal dialogues or reflections that a person has with himself to get to know himself better are called intrapersonal communication. On the other hand, interpersonal communication is the type of communication in which *"communicators are willing and able to share part of their individuality and to be aware of the individuality of others"* [127].

This is relevant for education given that, as authors such as pointed out in [128], a teacher who does not show closeness to students and who does not take the time to start a conversation with them in the classroom at an interpersonal level, can affect aspects such as their interest, motivation, and willingness to learn. In other words, the openness that a teacher shows (in terms of rapport and interpersonal communication) is directly linked to the perception that students have about the teacher's teaching abilities and the effectiveness of the learning process [129], [130].

Some teachers tend to resort to humor, to tell stories, or to show enthusiasm and sincerity, in order to establish rapport and to have a good interpersonal communication with their students. Others seek to strengthen their credibility with young people by showing an understanding of modern culture. These options contribute to the creation of a spontaneous and genuine environment, which favors student learning.

Although technologies can contribute to the development of rapport between users, there is a gap between the way students and teachers use them, better known as digital dissonance [129], [131]. This takes place given that young people tend to use technology in an open and intuitive way, which collides with the structured, controlled and, many times, artificial way in which it is used in schools. For example, to learn how to edit images or videos to upload to their Instagram or TikTok account, young people can consult their friends, watch a video tutorial, search for information on Wikis, or venture to click on different places on their mobile device until they achieve their goal.

To take advantage of technological means to establish rapport and to have a satisfactory interpersonal communication with their students, a teacher must resort to multimodal communication [132]. One of the assumptions of communication is that it is mono modal; that is, that the communicative exchange that takes place between people can only occur through a semiotic mode or resource (e.g., oral or written language). Multimodality refers to the use of different semiotic resources such as texts, audios, videos, photos, drawings, graphs, diagrams, infographics, emojis, GIFs, etc., to represent and communicate meanings.

Therefore, for a teacher to be able to communicate effectively with students through technological means, he or she must consider the following: (1) ways to foster the personal development of students through activities that contribute to the improvement of their self-concept, self-esteem, raison d'être, and/or well-being; (2) young people are not passive consumers of information but prosumers, that is, subjects who like to create, modify, and share content; and (3) the content used to communicate the information should preferably be

TABLE 4. Considerations for effective interpersonal communication.

Issues	Considerations
Personal development	How can classroom activities be linked to students' personal development? What approach/take should these activities have so that they are appealing enough to them on a personal level?
Students' prosumer role	How can students' technological skills be used in more advantageous ways? Are there any activities that can take advantage of their digital hobbies?
Multimodal resources	Are the resources contemplated to communicate the content to the students multimodal? Is the content varied enough for the information that is presented to be seen as attractive or striking for everyone?

multimodal, that is, it should not be just text or video [129], [133], [134].

After carrying out a brief review of the literature, with the help of the participants, the following list of considerations (Table 4) was created. By consulting it, a teacher can consider the basic aspects necessary to establish an effective interpersonal communication with students through technological means.

D. SECOND VERSION OF THE MODEL

We worked on an improved version of FORTAGONO (fig. 4). This new version aims to help teachers to make better use of the resources available to them, both human and technological, when planning a session (face-to-face, blended, or remote). The first step a teacher must take is to define the unit of learning. One may be able to do so if one knows the topic (or area of knowledge) and has a brief description of the content to be covered during the session. The second step is to select the educational goal using the updated version of Bloom's Taxonomy. For this, it is recommended that the teacher reviews which categories and subcategories it will be possible to achieve during the session. Like in the previous iteration of the model, the decision of what learning theory and teaching style/method to follow is up to the teacher.

The third step is to consider the students' information consumption habits, as well as how they think, act, approach problems, and set goals. This step can be complicated if the teacher has not had the opportunity to interact with the students beforehand. However, one may use previous experiences as reference.

The fourth step is to prepare the material that will be used before, during, and after the session. It is worth mentioning that it is not necessary for teachers to design or create their own content; it can be obtained from other sources such as digital repositories, blogs, wikis, etc. However, it is important for teachers to choose the type of materials that will be used (e.g., videos, images, diagrams, simulations, video games, texts, etc.). This to verify their availability, functionality, and ease of use. Subsequently, teachers must establish their order of consumption, following the requirements for transmedia content (i.e., for content to be divided into pieces, to be presented through different channels, to provide a unified consumption experience, and to avoid redundancy).

TABLE 5. Technology that participants have at their disposal.

Technology	Percentage
Mobile phone	100%
Wireless Internet	57.34%
Laptop	53.15%
Desktop computer	20.98%
Printer	14.69%

The fifth step is to review the technology that both teachers and students have at their disposal. This implies the need to evaluate the hardware and software in terms of accessibility and availability, among other factors. The sixth step is to choose the most appropriate technological mediation modality to teach the session. This may be achieved through the use of the Modalities Matrix compiled during the first workshop (Table 2). It should be noted that there are times when a session can be executed following two or more mediation modalities. In this case, the teacher must assess which is the most pertinent or appropriate according to the context and circumstances.

The seventh step is to plan the flow of activities, taking into account the considerations for the instructional design of a technology-mediated session that we compiled during the second workshop (Table 3). The eighth step is to define the communication strategy that the teacher will follow, preferably, after having considered the information on effective interpersonal communication found in Table 4.

E. OBTAINING THE OPINION OF STUDENTS

To learn the opinion that students might have regarding a session planned with the second version of FORTAGONO, between February and March 2021, an exercise was carried out with the support of six of the teachers who were part of the second workshop. We invited them to prepare one of their classes making use of the second version of the model. Next, we asked them to send a 20-item questionnaire to their students through which we collected information related to: (1) their demographic data, (2) technology they have at their disposal, (3) technological resources used by teachers, (4) their learning experience, and (5) their suggestions for improvement.

1) RESULTS

A total of 143 students participated (53 men and 90 women) from elementary and high school, and undergraduate level. The average age of participants was 15.44 years. It is worth mentioning that all the participants have at least one device that allows them to surf the Internet and take classes online (Table 5).

Regarding the devices that the young people used to take the class: 117 (81.82%) used a mobile phone, 18 (12.58%) a

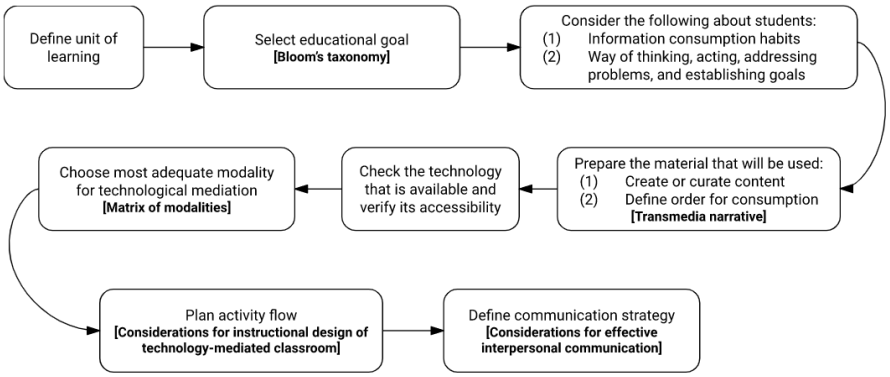

FIGURE 4. Graphic representation of the second version of the model.

TABLE 6. Digital resources used by teachers.

Resources	Percentage
Electronic books or PDF	60.14%
Websites	57.34%
YouTube	28.67%
PowerPoint presentations	27.27%
Specialized software (e.g., Mathematica, SPSS, Java, etc.)	16.78%
Blogs	4.90%
Facebook	2.80%
Instagram	1.40%
Video games	0.70%

TABLE 7. Assessment of the resources used by teachers (Likert-5).

Criteria	Result
Adequacy to the content or objective of the class	4.63
Attractiveness	4.33
Ease of use	4.59
Clarity	4.47
Contribution to learning	4.49

TABLE 8. Learning management systems (LMS) used.

LMS	Percentage
Google Classroom	80.42%
Knotion	11.89%
Moodle	4.20%
Blackboard	0.70%

TABLE 9. Things that students would like their teachers to change to improve the class.

Criteria	Percentage
The type of resources (e.g., web pages, social networks, videos, etc.)	37.06%
The way of presenting content	27.97%
The number of activities	27.97%
The variety of the content	21.68%
The type of activities	20.28%
The way resources are used in class	19.58%
The way of evaluating	19.58%
The length or duration of the class	16.08%
The type of content	15.38%
The style of teaching	2.10%

laptop, 5 (3.5%) an iPad, and 3 (2.1%) a desktop computer. An important aspect of FORTAGONO is the preparation of the materials that will be used by the students. In that sense, we asked students to enlist the resources that their teachers used during the test class (Table 6).

Using questions in Likert-5 format (1 being somewhat satisfied and 5 very satisfied), we asked students to evaluate the resources used by their teachers (Table 7). As part of technology-mediated education, it is common to make use of learning management systems (LMS). For that reason, we asked students to mention the LMS used by their teachers during the class (Table 8). Subsequently, through a question in Likert-5 format, we asked students to evaluate the ease of use of these LMS. The result of the assessment was 4.37.

Regarding the students' learning experience, using questions in Likert-5 format, we asked them to evaluate their satisfaction with the class and their overall learning experience. The results we obtained were: satisfaction 4.49 and experience 4.29. We then asked them what they would like their teachers to change to improve the class (Table 9).

Lastly, through an open question, we requested students to make suggestions regarding the aspects that they consider most important for a class mediated through technology to be ideal. In general, the students' responses revolved around the following aspects: (1) the resources used in class, (2) the activities, (3) the contents, (4) the teacher's actions, (5) the role of the student, and (6) the execution of the class.

In terms of resources, two criteria that students consider important when creating or selecting them are their variety and quantity. Speaking about the variety of resources, a student mentioned the following: "*I would like the teacher to pose problems related to the class, to ask questions during the video conference, in order to earn extra points in the activity. It would be a great idea. I think they should consider doing that*". Another student answered: *"It would be good if teachers included videos that explain the contents"*. A student directly mentioned a type of resource that he would like to see included: *"Let them teach us using entertaining yet educational games"*.

Regarding the activities, the key points that students suggest considering are the clarity of the explanation, that they be dynamic and fun, their variety, their extension/duration, their simplicity or degree of complexity, and that they be striking. In this regard, a student said the following: "*I would like for the explanations of the activities to be really easy to understand*". On the other hand, a student answered: "*I would like for the activities to be explained well, and for them to be like, dynamic, so that the class is more fun and thus we learn while playing*".

Regarding the contents, the elements that the students would want teachers to take into account are the clarity of the explanation, its variety, its simplicity or degree of complexity, and that it be striking. One student wrote the following: "*I would like to participate in a class with topics that are well explained and illustrated in an attractive way*". Another student said: "*I would like for the explanation to be clear, so that it is easily understood*".

Another important aspect for the students is the teacher's actions. The key points that participants highlighted were that the teachers know how to guide them through the learning process, that they be patient, that they are empathic, and that their explanations are brief. One student highlighted the following: *"Teachers should be patient with us when teaching"*. On the other hand, a student wrote the following regarding the relationship he would like the teachers to have with them: *"There should be trust, so the relationship would be beneficial for both parties"*. Another student responded: *"That the planning be striking, so that you learn in a good way, with activities that get your attention, that teachers explain the main concepts that were not understood"*.

Regarding the role that they would like to have during the class, the students highlighted the opportunity to have greater participation, to have a better relationship with other students, and to have a better communication with the teacher. One student described her ideal class as: "*A dynamic class with student input*". On the other hand, another student described her ideal class as follows: "*A class where there is communication and cooperation between students and teachers*". Another student said: "*A class where everyone wants to participate, without fear of being made fun of. Also a class where we are all united, and we have enough time to let off steam*".

Lastly, related to the execution of the class, the students mentioned the importance of having a lower workload and better scheduling. One student requested the following: *"Homework shouldn't be excessive, with sufficient time to turn it in"*. Another student responded: *"Make it short, dynamic, and with different activities"*.

2) ANALYSIS

Despite the fact that just over half of the students who participated in the exercise had a laptop (53.15%), not all of them used it to take the class (only 12.58%). A majority used their mobile phone (81.82%). This suggests a clear preference on part of respondents towards this type of device. On the other hand, in general, their assessment of the resources used by the teachers and of the educational experience was positive. However, they would want their teachers to use different types of resources, that their way of presenting the contents be more dynamic, and that the number of activities seen in each class be less.

According to the students who participated in this exercise, a technology-mediated class would be ideal if: (1) the resources/materials were varied and not excessive in terms of quantity; (2) the activities to be carried out were clear, dynamic, and fun; (3) the contents were varied and clearly explained; (4) teachers knew how to guide students through the learning process and were patient with them; (5) they were allowed to have more participation; (6) a work environment that favors cooperation among students was fostered; and (7) the workload was less and their schedule was not saturated.

F. INTERVIEWS WITH TEACHERS

To continue strengthening our model and to learn the opinion that different educators had about its second version, a series of semi-structured interviews was carried out. To facilitate the development of the interview sessions, a set of materials and probes were prepared (e.g., a PowerPoint presentation). To recruit participants, we invited teachers through local organizations. The selection criteria that we established for participation were the following: (1) to be currently working in an educational institution, and (2) to have experience teaching classes mediated through technology.

Sessions took place from September 2021 to January 2022. In total we had eight teachers, 4 men and 4 women, with an average age of 37 years. Participants teach in public and private institutions, and at different educational levels, from elementary to graduate school. It is worth noting that we had teachers who work with students with disabilities and who work in rural areas. We had the opportunity to speak with each one of them for approximately 90 minutes. Due to the pandemic, interviews took place through Google Meet.

The topics that were covered included: (1) ways in which the teachers prepare a technology-mediated class, (2) criteria they use to decide what to teach in their class, (3) strategies they follow to select the audiovisual material that they will utilize, (4) ways in which they define the order of the activities that they will carry out, (5) measures that they take

to ensure that learning occurs, (6) opinion they have about our model, (7) contexts or scenarios in which they consider that the model can be more useful, (8) possible benefits of implementing the model in schools, (9) greatest contribution of the model to teaching, (10) aspects of the model that they consider to be novel, (11) limitations they feel the model has, (12) things they would change or add to the model, and (13) their openness to learning how to use the model.

The information that was collected during the interviews was subjected to a qualitative analysis making use of techniques of grounded theory. Next, we present the categories that emerged as a result.

1) GIVING FEEDBACK THROUGHOUT THE PROCESS

A majority of the participants emphasized the importance of monitoring and following up on the different activities carried out both by the teacher and the students during the application of FORTAGONO (e.g., the selection of the educational goal by the teacher, and the exercises and tasks completed by the students). This in order to constantly verify the progress that is being achieved and, in this way, to be able to make adjustments if necessary.

One of the teachers mentioned the following in this regard: "*I would like to see how, a way to evaluate the educational goal that was established for that day... If it was achieved, I can continue... If we want the model to be used for the planning of a class throughout a semester, another module could be added, for evaluation. This evaluation would allow you to follow the model smoothly. Something like a kind of constant feedback. The feedback you need to be able to continue*".

Another of the interviewees replied: *"Evaluating should allow the teacher to correct what he does. If the evaluation does not help us to correct the course, then we would spend years without knowing if we are bad at something... Course correction lies at the core of the progress of the educational system, and also of teachers and their professional and individual improvement. This evaluation should give us data to provide feedback on our way of teaching... To the extent that one is aware that there are opportunities for improvement, everything can be better"*.

Institutions are communities in constant change [135]. Decision-making is one of their fundamental pillars, as it allows them to draw up strategies that serve as guidelines. The decision-making process implies, among other things, conducting activities such as reflection, evaluation, analysis, consideration of consequences, and weighing of alternatives.

Even though decision makers may have years of experience in a field or specialized training, they are exposed to biases such as confirmation bias, which can lead them to seek information that confirms their ideas or preconceptions, and consequently, to avoid data that contradicts them [136].

For this reason, it is recommended that the decision-making process be preceded by the execution of exploratory studies that allow decision-makers to know a situation in greater detail. Through the development of exploratory exercises of this nature, it is possible to detect and address, in a timely manner, the different problems that affect the people who are involved and the activities they carry out.

In the case of the technological mediation of the teaching and learning processes, constant feedback (qualitative and quantitative) can help a teacher adjust aspects such as the quantity or difficulty of the contents, or to determine the progress of the students.

2) FLEXIBILITY IN ITS APPLICATION

For participants, the steps included in the model made sense. They considered that they accurately reflected what they had been doing up to that point during the lockdowns. However, some of them mentioned the importance of changing their order as required by the context, environment, available resources, or the actors involved (e.g., students or the teacher himself).

In this sense, a participant said the following: "*According to the needs of the student, we could decide to execute a step before the one that was proposed. So having the flexibility to decide what to do next, how to move forward, might be a good idea. Although one of the steps (of the model) is planning the flow of activities, I think that its order should be flexible. Students could help us decide the way forward, that could help with their learning of the content*".

Another professor made the following observation: *"The way I see things, step 4 (preparing the material to be used) should come after reviewing the available technology. I tell you this because the decision of which materials you choose will be based on the needs of the student, that is, it has to do with access... This model that you presented to me is like a guide for teachers to prepare their work... It is a guide. A model is like a way to explain a phenomenon. It is a visual explanation. It is a concrete explanation of a phenomenon. So, this responds to the question of how the technological mediation of a class has been taking place and how it should take place, but like I told you, in scenarios like ours (rural school) that are not ideal because the area is not a rich area, you don't have quick access to everything (in terms of technology)"*.

The integration of technologies in education has resulted in a transformation in the way of teaching and learning. This is the case as technology can enhance the skills of its users. However, even though many people have devices such as smartphones and wireless Internet, there are sectors of the population that do not have guaranteed access to these resources. On the other hand, for people with a disability (physical or cognitive) the use of hardware or software may not be so simple. For this reason, it is necessary that models such as FORTAGONO allow for the process of planning classes mediated by technologies to begin from different starting points, depending on the needs of teachers and students or the context in which they find themselves.

3) PARTICIPATION OF OTHER STAKEHOLDERS

For some participants, the planning of classes occurs at faculty or board member meetings. For this reason, some of them suggested opening the model to include the participation of other stakeholders of education.

In relation to this point, one of the teachers mentioned the following: *"It would be interesting if it (the model) had an optional stage for when you want to consider teamwork, that is, when working in multidisciplinary groups. It would be very interesting if things were set in the model in this regard... It would be good if the model told you something like: 'first the group must agree before defining the unit of learning'. To reach an agreement between members of the faculty who will teach the same course... It would be interesting if there was an optional module for teamwork"*.

One of the teachers mentioned another group of stakeholders that, in her opinion, should be considered: parents. Based on her experience, she shared the following with us: *"It is important to foster study habits at home. In other words, I ask myself, how can I reinforce this part as a parent at home? Because sometimes we have a situation in which, we don't always have the kids with us in the classroom. So sometimes we see them for a week, and we don't see much progress because at home student learning is not being reinforced or followed up"*.

On the other hand, a teacher highlighted the following: *"Education is the product of a team. It is a team effort. For this to happen, there must be collaborations. In other words, education mediated through technology cannot depend on just one person. There must be a team behind us. A technological team, a pedagogical team, a psychological team"*.

To start working on a project, it is necessary to define who will be involved in its development. A simple way to do this is by thinking about what activities will take place. For example, in the case of education, during the definition of the contents that the students will cover as part of a subject, the authorities of the Ministry of Education (or its equivalent) may participate, as well as school officials and groups of teachers within the institution. Other stakeholders that could be considered (depending on the topic) may be companies, researchers, or the parents. Depending on who participates, how they do it, and in what parts of the process they do it, the results obtained (in terms of quality, extension, etc.) may vary. Therefore, models such as FORTAGONO must allow for the involvement of different stakeholders throughout their implementation.

4) WORKING WITH STUDENTS WITH SPECIAL NEEDS

Many of the teachers who participated during the interviews have worked with special needs students, such as students with disabilities, with psychological problems, or with learning problems. Hence, some of them requested that, in addition to the information that was already planned to be obtained from the students, a more complete assessment be carried out.

In this regard, a teacher responded as follows: "*I have been teaching online for a year and a half, and so far I have had good results... My students obtain good grades. I think I get good results when I teach in the classroom... However, there are socio-emotional issues that are going to unleash that have not yet been expressed by the students... Perhaps that would be missing from the model, a part where the emotional, the mental aspects are considered. I don't know what to call it... It would be important that in addition to contemplating the students' way of thinking, of acting, that problems in their way of thinking or physical problems be contemplated. In other words, I don't know if this model would apply to people who have special needs. Something like autism... I think that within step 3 (considerations of the students) a sub step could be added to contemplate the emotional situation and cognitive abilities of the student"*.

A teacher, who specializes in special education, said the following : *"It would be important to include a diagnostic test, a diagnostic test to see how the group is doing. To identify possible disabilities or difficulties students may have. Even more so in the case of students with certain areas for improvement... In this situation we must be flexible. The personal, family, and socioeconomic context of the student must be identified... We must find a way to do it so that the student does not end up with more lag than he or she may already have due to their conditioning"*.

One-size-fits-all curricula can create access barriers for students with some type of disability. That is why various experts propose adhering to Universal Design of Learning (UDL) to plan classes that are accessible and attractive to all types of students [1]. UDL is a framework that contemplates the devising of multiple and flexible means to: (1) access, present, or represent information, concepts, and ideas (i.e., the what of learning); (2) plan and develop tasks or activities (i.e., the how of learning); and (3) act, participate, or get involved (i.e., the why of learning) [137].

To plan a lesson following the UDL guidelines, teachers must: (1) use multiple strategies to present content, (2) have a variety of materials, (3) provide cognitive supports (e.g., instructional scaffolding), (4) consider different ways of learning, (5) anticipate the need to communicate through different media, and (6) provide flexible opportunities to assess progress [138]. In the case of technology mediated education, the goal of UDL would be to provide resources (hardware and software) through which all types of students can perceive, understand, navigate, and interact with the digital content of the classroom [1], [139].

G. THIRD VERSION OF THE MODEL

After obtaining the results from the student evaluation of a class planned with the second edition of FORTAGONO, as well as the feedback from new teachers during the interviews, we compiled a series of insights that allowed us to continue evolving our model. In its third iteration (fig. 5), FORTAGONO is a model aimed at planning a session (face-to-face, blended, or remote) and taking advantage of the available human and technological resources. To do this,

it contemplates the interaction between two types of operational modules: (1) central, those whose function is to serve as an axis or reference point for decision-making; and (2) global, which seek to serve as connective tissue.

Unlike its previous versions, on its third edition there is no predetermined path to follow. The order in which a module is covered can be defined according to the priority that one may want to give it. In other words, different trajectories can be traced according to the needs of every situation. This decision can be made by following heuristics similar to those used for route optimization, such as the Travelling Salesman Problem (TSP). That is, one may choose which path to follow based on the priority or relevance of the module (current or next) to cover.

Among the central modules are: (1) the students and their individual characteristics, (2) the unit of learning and educational goal, (3) the technology that will be available throughout the session, (4) the content to be covered, (5) the activities to be carried out and their flow, and (6) the communication between participants.

Once a teacher chooses a module to start with, he or she can define what modules will follow next, depending on factors like context, situation, constraints, priorities, etc. For example, if a teacher wants to plan a class for students with some kind of disability, he or she can start from the Students module. Depending on the specific disabilities, defining factors like the type or extension of the content to present can be challenging; thus, it would be better to continue with the Content module. Subsequently, the teacher may assess which module is best to continue the planning with taking into consideration the content.

On the other hand, global modules may be used to link the different nodes, or to improve the performance of a particular module. These are: (1) cooperation with other stakeholders, and (2) evaluation (qualitative and/or quantitative) of the objectives achieved or the percentage of progress achieved to date. Unlike the previous modules, these should be considered throughout the process.

It should be noted that, like in the previous two iterations, the choice of what learning theory and teaching style/method to follow depends on the teacher.

1) APPLICATION

To illustrate how the third iteration of our model can be used to plan a successful technology-mediated session, we present the following sample scenario. Tatiana is a Chemistry teacher at a public high school located in a rural area. To teach her classes, she likes to print exercises with instructions for students to solve in teams. However, during the COVID19 pandemic, she was forced to transfer her classroom exercise to digital media. Before the semester began, the school's administrative office asked all students to share their mobile phone number so that they could stay in touch with them. At the beginning of the semester, an academic staff told Tatiana that 20 out of 25 students in her group do not have access to a desktop or laptop computer. For that reason, she must verify that all activities can be conducted through mobile phones with Internet access.

Tatiana decides to work with FORTAGONO. First, Tatiana chooses the Technology module as a starting point. Thus, she proceeds to check that all her students have Internet access on their mobile phones. To do this, Tatiana sends them an email or SMS message to verify their current situation. After that, using the matrix of mediation modalities (Table 2), she chooses to teach her class by following the distance education modality. That is, as a teacher she must provide the following to her students: (1) instructions for the activities they must complete, (2) order of consumption of the materials, and (3) evaluation instruments.

With that information at hand, Tatiana chooses the Learning module as the next node to work on. She defines the unit of learning to be covered in her class. This time they will have to learn about ''classification of matter''. After reviewing the syllabus, she consults Bloom's Taxonomy, selecting the ''understand'' category and the ''exemplify'' subcategory. That is, the goal of the class will be for students to understand the topic, for which they must provide examples. Later, Tatiana chooses to continue with the Students module, so she considers the personal characteristics of her students. She has had the opportunity to work with them before, so she knows that they like to consume material through social networks, such as memes and Tik Tok videos.

On the other hand, regarding her students' way of thinking, acting, approaching problems and setting goals, Tatiana defines the following: (1) since her students are not inclined to reflect, she should present them with simple problems that they can solve independently; (2) given that her students are open to cooperating with each other, she can take advantage of their solidarity so that they solve the exercises in groups; (3) as there are clear leaders in the group, she can rely on them to ensure that the content reaches everyone; and (4) since several of them tend to get discouraged when faced with difficult challenges, she decides to lower the difficulty of the exercises.

With little time left to prepare the material for the class, Tatiana decides to search for resources on the Internet and thus complete the Content module. Soon after, she finds presentation slides and two videos that talk about the subject. Inspired by transmedia storytelling, she defines the order in which materials should be consumed. The first video presents the topic of classification of matter in a simple way, so it will serve as an introduction. The presentation slides delve a little deeper, so they can be viewed later. The second video answers some of the most common questions, so it can serve as optional reference material.

Once the class material has been prepared, taking advantage of the table of considerations for the flow of a session (Table 3), Tatiana continues with the Activities module and begins to plan the development of the exercises (Table 10). After that, as part of the Communication module, she defines that she will communicate with the students through the Telegram mobile app. To ensure that the communication she has

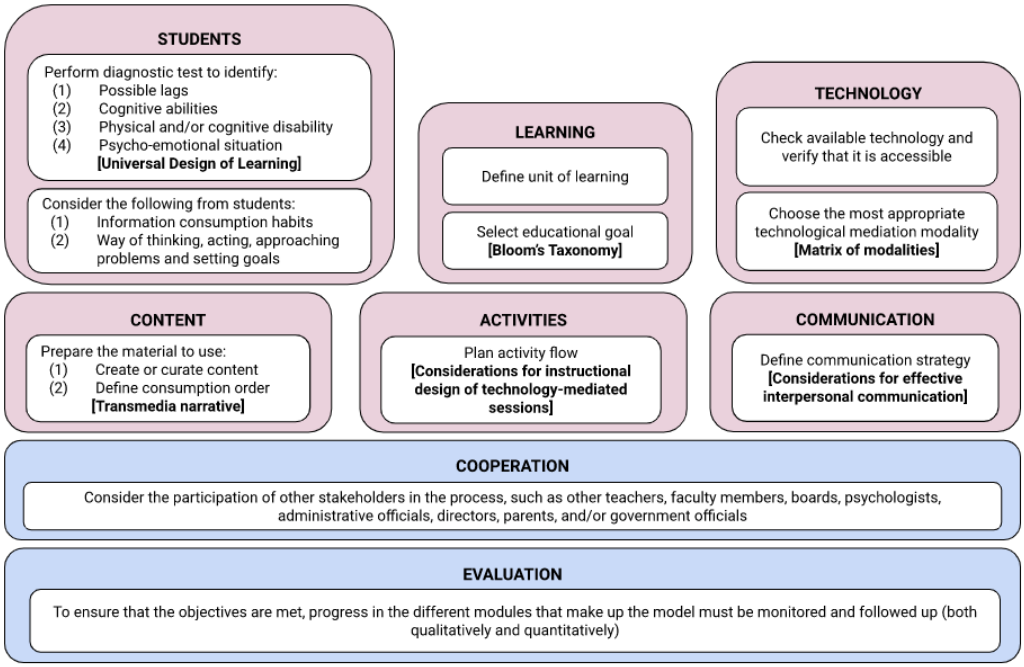

FIGURE 5. Graphic representation of the third version of the model, with central modules highlighted in pink and global modules in blue.

with her students is effective, she takes into account aspects of their personal development, their role as prosumers, and multimodal resources (Table 11).

Regarding the Cooperation module, she decides to ask one of her peers to help her review what she has prepared, so that she may get feedback. Finally, to complete the Evaluation module, Tatiana decides that she will evaluate what the students have learned through a questionnaire with questions prepared using the Google Forms tool.

IV. RELATED WORKS

To better understand how FORTAGONO relates to similar projects within the field of Computer Science (CS), we carried out a systematic (non-exhaustive) review of the literature. The information we collected was subsequently analyzed.

Among the publications that were consulted are conference proceedings, journals, and books. These were accessed through services like ACM Digital Library, IEEE Xplore, ScienceDirect, and Google Scholar. The search terms we used were ''strategy'', ''model'', ''method'', ''methodology'', ''framework'', ''steps'', ''process'', ''procedure'', or ''guideline'' in combination with ''learning'', ''teaching'', ''education'', or ''pedagogy''.

After separating the results from those that were not related (e.g., machine learning, agent learning), we proceeded to select documents that met the following criteria: (1) the contribution of the work had to be related to teaching and/or student learning; (2) the contribution had to be original (i.e., different from other selected works); and (3) the focus of the manuscript should be generalizable or universal (i.e., not limited to a single or unrepeatable situation). It should be noted that preference was given to full papers over works in progress. In total, we found 488 documents.

The next step we took was to classify the manuscripts according to their relevance with respect to the objective of the FORTAGONO project (i.e., to contribute to the successful technological mediation of the teaching and learning processes). We marked as ''not relevant'' works that mention the keywords we were looking for but whose topic, scope, content, findings, or contribution were not directly related to the objective. Consequently, we regarded as ''relevant'' documents whose topic, scope, content, findings, and contribution were closely related to the objective. In the end, we were left with 55 manuscripts. Next, we present a summary of our findings.

A. TECHNOLOGY FOR TEACHING

By technology for teaching, we refer to projects focused on the use of hardware or software by teachers, to teach. For educators looking to teach a class using technology, the challenge is not in defining 'what' devices they will use but 'how' they will do it. This is because they are responsible for ensuring that the pedagogical models they choose, the curricula they develop, the activities they plan, and the evaluation methods they apply, regardless of the type of technology they use, motivate their students to learn and make use of their cognitive abilities such as critical thinking and creativity [140]. For this reason, when selecting a device or service it is recommended to keep in mind factors such as the way students act, their way of reasoning or reflecting, how they feel when they are involved in collaborative activities, their previous knowledge, etc. [140], [141]. Other factors that can

TABLE 10. Flow of activities for the chemistry class.

Aspects	Considerations
Technological availability	All students have a mobile device with Internet access.
Mediation modality	Distance education
Activities for the session(s)	1. Read the instructions sent by the teacher 2. Watch the first video 3. Consult the presentation slides 4. If you have doubts, check the second video 5. Answer the questionnaire in groups
Theoretical framework	To prepare the session, the teacher is inspired by Behaviorism. Since the quiz will contain multiple choice questions, students will be able to see the correct answers right after finishing. In addition, the teacher decides to give incentives to groups that get outstanding scores.
Methodology	For the development of the session, inspired by gamification, Tatiana decides to implement a point system and medals. This in order to encourage student participation.
Limitations	Instead of giving students the freedom to choose who would be on their teams, she grouped her students according to their abilities.
Evaluation	To evaluate student performance, the teacher prepared a questionnaire with multiple choice questions. Therefore, if they understand the material of the videos and the presentation, they will be able to respond without much trouble.
Desired result	Tatiana hopes that at the end of the session her students have understood the basic concepts.
Reflection	Once all the groups have finished, she will send them messages to reinforce the key points that she thinks were less clear.

TABLE 11. Aspects considered by Tatiana for effective communication.

Aspects	Considerations
Personal development	Several of the students in her class are natural leaders, so she decided to put them in charge of a group. To encourage everyone to participate, Tatiana decides to give extra points to those who provide evidence of their work. For example, one point is awarded to whoever sends a screen capture of the conversation they have with their classmates, demonstrating their participation.
Students' prosumer role	Several students upload videos and memes to social networks. Therefore, Tatiana decides to offer an extra point to whoever creates a meme or video related to the topic seen in class.
Multimodal resources	To reinforce their learning, the teacher decides to use videos and a presentation to present the material.

be considered include the duration of the intervention, the role to be played by the educator, the reward methods used, the teaching context, the type of interaction, the objectives, the instructions, the sociocultural context, and feedback from previous courses/classes [140], [141], [142]. In other words, educators must consider various aspects along with the pedagogical objectives of the class.

After reviewing the relevant literature, we identified different approaches that enable teachers to teach through technology. Table 12 shows a summary of the similarities and differences that we found between the related works and FORTAGONO. A common approach is to ask teachers to: (1) plan their lesson, (2) select the type of technology they will use, (3) configure the technology, (4) prepare the material or content that will be consumed, and, optionally, (5) tailor the class and content to student liking to foster engagement [41], [60], [77], [81], [82], [143].

Another common approach is to have teachers ask their students to: (1) review the material, (2) complete activities, (3) take quizzes or tests, (4) provide feedback on the lesson, and, optionally, (5) collaborate with their peers [61], [75], [78], [89], [90], [144], [145].

A third common approach is to have teachers: (1) identify characteristics of their students (e.g., expectations, prior knowledge, experience), (2) analyze the content they will teach, (3) design their class, (4) prepare the material to be used, (5) evaluate results, and, optionally, (6) consider the devices used by the students [64], [146], [147], [148], [149].

On the other hand, we found approaches that focus more on pedagogical aspects such as the instructional design or content design/preparation. In [150] a framework is presented that consists of the following phases: (1) conceptualize the class or course, (2) create activities and resources, (3) consider student-teacher communication, (4) design an environment that encourages collaboration, (5) consider how to implement the online course, (6) combine all the ideas, and (7) evaluate progress in a real learning context.

In [69] a process consisting of the following steps is outlined: (1) provide students with concepts and examples, (2) explain them to the students, (3) answer questions, (4) clarify complicated ideas and concepts, and (5) ask students to complete a task using software. And in [151] a methodology is presented that is divided into the following steps: (1) create or curate material, (2) review the material with peers (e.g., in faculty or board meetings), (3) evaluate learning outcomes, and (4) encourage collaboration.

Similarly, we identified approaches that focus more on student work. This to promote their autonomy. An example of this is the methodology presented in [83], which consists of the following steps: (1) present the course program, (2) create an online classroom, (3) share with the students the activities that they must perform, (4) ask students to work on assignments, (5) communicate with students through social media, (6) ask students to collaborate with others, (7) ask students to present their projects, and (8) evaluate their performance.

Another example of the above is the framework that appears in [152], which consists of the following phases: (1) adapt the material for online and offline access, (2) present students with real world problems, (3) ask students to investigate ways to solve these problems, (4) encourage student-student communication, (5) monitor progress, and (6) provide learning environments and opportunities.

TABLE 12. Comparison of FORTAGONO with similar approaches oriented to teaching.

Approaches	Factors							
	Students	Learning	Technology	Content	Activities	Communication	Cooperation	Evaluation
FORTAGONO	✓	✓	✓	✓	✓	✓	✓	✓
[41, 60, 77, 81, 82, 143]	-	✓	✓	✓	✓	-	-	-
[61, 75, 78, 89, 90, 144, 145]	-	✓	-	✓	✓	-	-	✓
[64, 146, 147, 148, 149]	✓	✓	✓	✓	✓	-	-	✓
[150]	-	✓	✓	✓	✓	✓	-	✓
[69]	-	✓	-	✓	✓	-	-	-
[151]	-	✓	-	✓	✓	-	-	✓
[83]	✓	✓	✓	-	✓	✓	-	✓
[152]	✓	✓	✓	✓	✓	✓	-	✓
[153]	-	✓	✓	-	-	-	-	-
[154]	-	✓	✓	-	-	-	-	-
[91]	-	✓	✓	-	✓	-	-	✓

TABLE 13. Comparison of FORTAGONO with similar approaches oriented to learning.

Approaches	Factors							
	Students	Learning	Technology	Content	Activities	Communication	Cooperation	Evaluation
FORTAGONO	✓	✓	✓	✓	✓	✓	✓	✓
[79, 151]	-	✓	✓	✓	✓	-	-	✓
[70, 157]	-	✓	-	-	✓	-	-	-
[59, 63, 76, 143]	-	✓	✓	-	✓	-	-	✓
[31, 50, 62, 86, 136]	-	✓	-	-	✓	-	-	✓

Finally, we encountered approaches that prioritize technology selection and implementation. An example of this is the guide shown in [153], which consists of the following steps: (1) learn about new technologies, (2) find appropriate technology, (3) consider pedagogical aspects, (4) identify the capabilities of the devices available to students, (5) consider the infrastructure available in the institution, and (6) create learning environments.

In [154] a guide is presented that includes the following steps: (1) investigate the costs of the infrastructure, (2) establish the requirements in terms of usability, (3) ensure the adequacy of the devices, (4) develop procedures to manage teamwork, (5) provide technical support to students, (6) promote collaborative and group learning, (7) search for applications that meet the requirements of the curriculum, and (8) ensure the security and privacy of information of the users.

And in [91] the following series of steps for m-learning is presented: (1) understand the technology to be used, (2) analyze the requirements of the activities, (3) translate

requirements into a technology use strategy, (4) prepare evaluation forms, and (5) evaluate student activities.

As can be seen in table 12, although these approaches cover factors related to learning and most address aspects of technology, content, activities, or evaluation, unlike FORTAGONO, few of them touch on issues related to the individual characteristics of the students or communication between participants, and none of them work with aspects related to cooperation with other stakeholders.

Another important difference is the depth with which these approaches address the aspects. To exemplify this, let us discuss the Students module. To cover this aspect, in FORTAGONO the execution of diagnostic tests (to identify lags, cognitive abilities, disabilities, etc.), and the assessment of personal factors (e.g., information consumption habits, way of thinking, etc.) of the students is contemplated; all of this in light of the Universal Design of Learning (UDL) framework.

Nevertheless, in the case of the previously mentioned approaches of technology for teaching, this is reduced to identifying some characteristics of the students (i.e., expectations, previous knowledge, and experience) or considering what grade they are currently in.

Other example is what occurs with the Communication module. To cover this aspect in FORTAGONO, one must define a communication strategy based on considerations for effective interpersonal communication, which contemplates factors related to the students' personal development, their role as prosumers, and the use of multimodal resources. On the other hand, for the approaches of technology for teaching, they only suggest having student-teacher communication, using social networks, or encouraging communication between students. Lastly, it is worth mentioning that none of these approaches has gone through more than one iteration.

B. TECHNOLOGY FOR LEARNING

We use the term technology for learning to denote projects related to the use of hardware or software by students to learn. As humans, we tend to learn better when we live experiences in which we have an action to take or a problem to solve, get emotionally involved in the process, and then have the opportunity to explore and try new things [37]. This reality implies that learning has both cognitive and affective components. Every student has their own style of learning, which reflects their way of absorbing and processing information. The term learning style is used to refer to the general, individual, natural, habitual, and preferred ways a person has of concentrating, absorbing, internalizing, processing, and retaining new information (and skills) or coping with problems [58]. Among the basic modalities for information processing and learning, the following stand out: visual (learning by seeing), auditory (learning by listening) and kinesthetic (learning by doing), each with specific characteristics [57].

Some of the factors that can affect (positively or negatively) student learning include: (1) the content, in terms of its organization, presentation, relevance, complexity, and accessibility; (2) the activities to carry out, in terms of their adequacy, duration, difficulty, sequence, interactivity, and opportunities for self-reflection that they provide; (3) interaction with third parties, in terms of collaboration, and openness to share; (4) personalization, in terms of control by the student and the opportunity to customize the experience; (5) technology, in terms of operability, aesthetics, feedback, accessibility, and appropriateness with respect to the educational objective; (6) the physical location in which learning takes place, in terms of space, context, availability of resources, and comfort; (7) the teacher, in terms of attitude, knowledge, skills, competencies, and availability; (8) the educational institution, in terms of the organization itself as well as the administrative processes related to the student's passage through it; and (9) the students themselves, in terms of their attitude, knowledge, skills, competencies, previous experiences, expectations, and motivation [74], [155], [156].

After completing a review of the literature, we identified different approaches that seek to favor student technology-mediated learning. Table 13 shows a summary of the similarities and differences that we found between them and FORTAGONO. A common approach is to ask students to: (1) receive instruction, (2) consult material, (3) carry out the activity, and (4) be evaluated, all this through a platform or system [79], [151]. Another approach, of a more experimental nature, consists of the following steps: (1) experiment through collaborative inquiry, (2) create awareness through the evaluation of information, (3) make sense of what has been learned by reflecting on the information, and (4) grow and change by analyzing and conceptualizing what has been learned [70], [157].

For some authors, the personalization of the educational experience is very important. This can be seen in the following approach: (1) enter the system or platform, which allows for the adjustment of details such as the student's profile; (2) consult activities; (3) carry out activities, with the opportunity to redo them; (4) receive feedback; and, optionally, (5) collaborate with others [59], [63], [76], [143].

Other authors seek to promote problem-based learning. The steps that they usually contemplate in their approaches include: (1) identify the facts, (2) represent the problem, (3) generate hypotheses, (4) plan and execute a solution, (5) identify gaps in knowledge, and (6) reflect on the process [31], [50], [62], [86], [136].

As table 13 shows, although these approaches cover factors related to student learning and the activities they carry out, and most address aspects of technology and evaluation, unlike FORTAGONO, few of them touch on issues related to the class content, and none of them deals with aspects related to the individual characteristics of the students, communication between participants, or cooperation with other stakeholders.

On the other hand, like in the previous case, the depth with which these approaches address the aforementioned aspects is less in comparison to FORTAGONO. To exemplify this, let us talk about the Technology module. In the third version of our model, the following is contemplated: (1) to check the technology that is available, (2) to verify its accessibility, and

(3) to choose the most appropriate technological mediation modality using the Matrix of modalities (Table 2). However, in the case of the previously mentioned approaches of technology for learning, this aspect boils down to taking advantage of the devices at hand or finding a system or platform that allows for adjustments.

In the case of the Cooperation module, FORTAGONO requires one to consider the active participation of other stakeholders throughout the process, including other teachers, psychologists, school officials, etc. While the approaches of technology for learning do not address this aspect explicitly or directly. Lastly, it is also worth mentioning that none of the approaches mentioned in this subsection has gone through more than one iteration.

V. DISCUSSION

A. OVERVIEW

We started this project with the intent of investigating what is needed for the teaching and learning processes to successfully take place through technology, and how these processes should be carried out.

After a four-week workshop with teachers from different schools and levels, we carried out a qualitative analysis of the information we compiled. As a result, FORTAGONO emerged: a model for the successful technological mediation of the teaching and learning processes.

Following recommendations found in [13], [14], and [15], to strengthen the usability and effectiveness of the model, we held a second workshop with new teachers. With the information we obtained, after a new qualitative analysis, a second version of the model emerged. To see what students and teachers who have had the opportunity to participate in online classes during the pandemic thought about FORTAGONO, we carried out an assessment exercise (a questionnaire for the students and interview sessions with teachers). And just like in the previous two cases, we conducted a qualitative analysis of the results and derived a new version of the model. Lastly, to exemplify the use of this third iteration, we presented a sample scenario.

By implementing the eight modules that integrate FORTAGONO, teachers may be able to plan a session (face-to-face, blended, or remote) from scratch, and take better advantage of the resources at their disposal (human, pedagogical, and technological). On the other hand, by using its modules as a guideline, teachers can evaluate an existing planning. This to analyze what can be improved in it in terms of delivery or execution. Therefore, FORTAGONO may be used for both planning and analyzing technology-mediated sessions.

To explore how FORTAGONO relates to similar projects within the field of CS, we carried out a semi-exhaustive, systematic review of the literature. The approaches we found have the following characteristics: (1) all of them contemplate factors related to learning; (2) most address aspects related to content, activities, technology, or evaluation; and (3) some cover elements connected to students or communication. Unlike FORTAGONO, none of them contemplates collaboration with other stakeholders, none addresses the eight modules in their entirety, none reaches the same depth in the aspects covered by our model (e.g., how to work with students with disabilities, what to do to teach in rural areas), and none have gone through more than one revision.

B. BENEFITS & LIMITATIONS

The successful adoption and eventual integration of technologies in a sector (education, work, health, etc.) may potentially be limited by two factors: the amount and type of equipment that is available, and the skills that users have to properly use it (i.e., digital skills). That is why for people whose field is not directly related to CS, this can represent a great challenge. Hence the importance of having approaches that allow for the balancing of different factors that may affect the technological mediation of an activity.

Although there may be individuals who in practice (thanks to their education, skills, and experience) are capable of covering different aspects/factors contemplated in FORTAGONO without the need to consult the model, they are not the common denominator. As evidenced in [8] and [9], many still struggle to overcome different barriers to teach with technology. On the other hand, the execution that these individuals may carry out of the aspects/factors could be uncoordinated, unharmonious, or unsystematic, which in turn limits the results they may obtain. Therefore, it is important to have formal strategies that allow all types of teachers (i.e., regardless of their background in terms of technological skills, the technological resources available to them, the educational level at which they teach, the type of students they have, the geographical location they are in, etc.) to satisfactorily mediate their classes with technology.

FORTAGONO emerged from the thoughts and opinions of a diverse group of teachers and students (i.e., from both public and private institutions, who teach/study at different educational levels, etc.) who have experienced technology-mediated education first-hand. Although it is possible that, after implementing it *'in the wild'*, it will be necessary to make adjustments to the model, in its current form it can serve as a starting point for teachers to take advantage of the resources at their disposal (human, pedagogical, and technological) and successfully teach classes mediated by technology.

In this sense, FORTAGONO acts as a tabula rasa: an approach that can potentially allow all types of teachers to teach technology-mediated classes. In other words, even if teachers do not master (or do not have access to) one or more resource, they can use FORTAGONO to identify what they have and what they lack, and thus look for ways to solve their deficiencies.

Since this model can be implemented regardless of the level of technological training of the teacher or the type of infrastructure available, it may be suggested that FORTAGONO does not condition or distort the teaching and learning processes. In other words, FORTAGONO may

contribute to the achieving of a minimum viable product (in this case a class) that adjusts to different conditions and needs.

Another benefit that FORTAGONO can represent for education is that by adapting to student characteristics and their learning needs, it favors the teaching and learning processes to unfold in a more organic and ergonomic way. That is, thanks to its flexible nature that allows one to organize and reorganize its parts, it helps teachers and students to level the playfield as they progress. For this reason, FORTAGONO may be compared to a Lego set, as it allows one to accommodate/distribute its pieces as one sees fit.

As FORTAGONO can be adapted to different contexts and conditions (economic, cultural, etc.), it could be used for the formation and management of comprehensive educational policies. That is, policies that contemplate the participation of schools whose infrastructure and/or curricula do not meet the minimum established for other institutions (e.g., rural schools, tele-secondary schools, multi-grade schools, etc.). In addition to that, this could potentially enable countries or regions whose development is limited to participate in current technological advancement (e.g., the adoption of new digital skills for teachers).

On the other hand, FORTAGONO may be used as a tool to estimate the risks a teacher may face when trying to mediate the teaching and learning processes. If utilized as a checklist, teachers may be able to anticipate problems and prepare for them in the best possible way. In this sense, FORTAGONO acts as an equalizer, as it has the potential to empower people to face challenges linked to the technological mediation of education.

In addition to that, FORTAGONO may be used as a barometer that allows monitoring the process of adoption and integration of technologies in an institution. This given that as its various aspects are covered, different needs will be solved, thus it could be possible for institutions to use it to estimate the degree of progress that has been achieved (i.e., milestones).

The present work has the following limitations. First, since it is a new model, it is not possible for us to discuss best scenarios or contexts for its implementation. Second, as the third iteration of the model has not been tested yet, it is not possible for us to talk about best practices of use. Third, given that it is a model in constant evolution, it is possible that future revisions will reveal the need to add or adjust modules/conditions.

C. TOWARDS THE DIGITAL TRANSFORMATION OF EDUCATION

Although they are currently seen as rare or for specific uses (e.g., entertainment), technologies such as virtual reality, augmented reality, artificial intelligence, robots, and video games have become increasingly common [158]. This implies that they will also begin to be used by all kinds of people and for all kinds of purposes. Hence the need to ask ourselves the following question: As a society, are we prepared to teach and learn through them? What will happen when new hardware or software arrives on the market and its use becomes widespread? In other words, as argued in [51] and [159], the digitization of education demands the formulation of innovative approaches that favors or give rise to the development of new skills linked to the knowledge society in an increasingly digital world (e.g., Facebook's dreamed metaverse).

For a society to be considered a true knowledge society, it must enable all kinds of people (regardless of sex, age, religion, physical and cognitive abilities, etc.) to have the necessary capacities not only to acquire information, but also to also to transform it into knowledge and understanding, which in turn allows them to improve their quality of life and their means of subsistence [51], [159]. Derived from this concept, we can say that, in a knowledge society, the effective integration of technologies in schools and classrooms must contribute to the transformation of the teaching and learning processes, and thereby favor the empowerment of students and teachers.

In other words, technology has the potential to contribute to the transformation of societies by improving the access, preservation, and sharing of information and knowledge. In the case of education, this digital transformation will take place when teachers and students are able to use technology (critically, collaboratively, and creatively) to create new knowledge and devise innovative strategies to solve all kinds of problems.

An educational institution can be considered transformative if it becomes a knowledge organization, where all members have the opportunity to learn. That is, a space in which teachers are seen as model students, as facilitators, and producers of knowledge, constantly dedicated to experimentation and innovation, in collaboration with their colleagues and other experts, with the intent of producing new knowledge in their formative areas.

Teachers will be transformative when they are able to, for all types of students: (1) create learning environments that foster lifelong learning; (2) use digital tools to collaborate with students and other education stakeholders; (3) use digital tools to track and assess student contributions to learning in the knowledge community; (4) encourage students to develop their own digital tools and resources for learning; and (5) encourage an open flow of information for all stakeholders through appropriate communication channels.

Students will be transformative when, through technology, they become able to: (1) trace their own learning trajectories; (2) conceive, create, apply, and follow innovative plans and strategies to solve problems; (3) develop new skills needed for problem solving; (4) critically analyze information and reflect on complex issues; (5) create new knowledge; (6) work critically, collaboratively, and creatively with others; and (7) organize, express, and exchange ideas in different ways and through different media.

D. FUTURE WORK

There is still much we can do to contribute to the consolidation of FORTAGONO and its eventual transformation into

a framework for the digital era. Among our plans for the future is the implementation of the third version of the model for the preparation of classes with students. To achieve this goal, we intend to teach teachers to use it in a new series of workshops. In addition to that, we plan to evaluate how much our model contributes to the digital transformation of education. This through evaluations with teachers, students, and other stakeholders.

At times, educational institutions themselves define the content and scope that school subjects will have. That is, teachers do not always have the freedom to decide what will be taught or how. Hence, we are interested in exploring the applicability of the model under these circumstances. Another important aspect to study is the impact that good and best practices can have. There are professors who, in their pedagogical exercise, have successfully addressed problems related to technological mediation of education without the help of models or methodologies. Therefore, as part of our future work, we plan to look for such cases to get their opinion about the model and see how they can contribute to its improvement.

FORTAGONO is a model that is divided into modules which, in turn, contemplate different elements. As part of our future work, we are interested in studying the importance of all its components, in addition to their individual contribution to the development of a successfully technology-mediated session and to the achievement of meaningful/deep learning in students. For example, it would be interesting for us to be able to catalogue transmedia elements based on their contribution to teaching and learning.

We are also interested in deriving complementary products from FORTAGONO. An example of this would be lists of digital skills linked to the technological mediation of the teaching and learning processes. Furthermore, these lists could eventually serve to measure the degree of adoption of the model.

Other aspect we would like to evaluate is FORTAGONO's user experience. That is, to explore what users of our model think about it after using it to plan a session. For this purpose, we intend to make use of approaches similar to the ones shown in [122] and [123].

FORTAGONO is a model that, methodologically and operationally, seeks to contribute to the technological mediation of the teaching and learning processes. Having emerged from the experiences and opinions of teachers and students from different backgrounds, it harmonizes with any learning theory (behaviorism, cognitivism, constructivism). Likewise, it is compatible with any teaching style or method (e.g., based on competencies, standards, performance, results, outcomes, objectives, etc.). It should be noted that, the decision of what learning theory or style/method to follow depends on variables such as the type or complexity of the content, timing, budget, context, or the teacher's preferences, among others. As part of future work, we plan to explore under which learning theories and which teaching styles/methods FORTAGONO yields the best results.

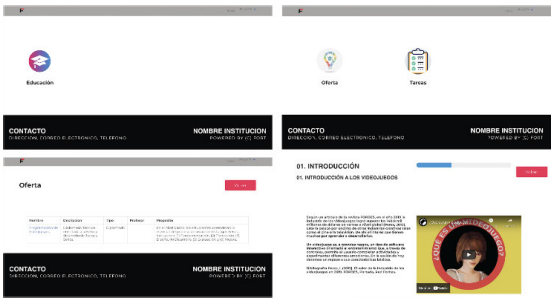

FIGURE 6. Screenshots of the FORTAGONO platform.

Lastly, we plan to investigate whether the model contributes to the development of personal skills and values in teachers and students such as autonomy, commitment, empathy, enjoyment, mastery of a subject, enthusiasm, emotional state, cognitive skills, motivation, personal attitude, and productivity, among others.

1) CUSTOMIZED PLATFORM

After reviewing different specialized software, we believe that currently there is no single tool that could allow us to make the most of the model and its modules. For this reason, as part of the FORTAGONO project, we are working on the creation of a new personalized platform using Cloud Computing technology. In Fig. 6 one can see screenshots of the prototype of the new FORTAGONO platform.

It is worth mentioning that the FORTAGONO platform will have two versions: student and teacher. This in order to facilitate the development of activities for both stakeholders. In addition to that, the platform will integrate various functionalities that will allow users to carry out all their activities without opening and closing new tabs or windows on their web browser.

We are currently testing designs and functionalities as part of participatory design workshops. Once we have completed a prototype, we plan to test it with students and teachers for the execution of one or more technology-mediated classes.

VI. CONCLUSION

A few years ago, some authors suggested that, in the not-too-distant future, the number of people who would learn using specialized software would grow significantly. Due to the spread of the COVID-19 virus, that future caught up with us. Most face-to-face activities were suspended worldwide. In the case of the educational sector, this led public and private institutions to seek strategies to migrate their activities to digital environments. However, even though both teachers and students make use of different types of devices in their daily lives, many find it difficult to teach/learn through them due to limitations such as their availability, accessibility, or ease of use, among others.

Driven by the interest of answering two research questions (What is needed for the teaching and learning processes to successfully take place through the use of technology? How should these processes be carried out?) and inspired by techniques for participatory design, we conducted a series of

activities including workshops, evaluations, and interviews. After conducting a qualitative analysis of the insights we obtained, we were able to derive a model for the successful technological mediation of the teaching and learning processes that we called FORTAGONO.

This model has gone through three iterations that were carried out to strengthen its usability and effectiveness. To learn how FORTAGONO relates to other similar projects in the field of CS, we conducted a semi-exhaustive, systematic review of the literature. To our knowledge, FORTAGONO is the only approach of its kind.

Our goal is to continue evolving and improving our model. This to develop a framework that meets the criteria for the digital transformation of education. As part of our future work, we have planned the realization of new workshops, its application for the planning and execution of classes, and the creation of a tailor-made platform to take advantage of its different modules.

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FRANCISCO LEPE-SALAZAR is currently the Managing Director of Ludolab, the Director of the Observatorio Nacional de la Industria de los Videojuegos with DevsVJ MX, a Creator and an Organizer with International Contest Games4Empowerment, a Founding Member of the Educational Program Código Frida, and a Teacher with the University of Colima, Mexico, and the Deggendorf Institute of Technology, Germany. His research interests include entertainment computing, human–computer interaction, and user empowerment.

TANIA CORTES-ALVAREZ is currently the Director of Cognos+, the Centro Multidisciplinario de Investigación y Evaluación de Politicas Públicas A.C., a member of the Internet Society Chapter Mexico, an Ambassadress of the International Program Technovation Girls, partner of EvalYouth, and a member of Observatorio TIC with the University of Colima, Mexico. Her research interests include the social functions of technology and digital humanities.