Journal of Information Technology Education: Research

An Official Publication of the Informing Science Institute InformingScience.org

JITEResearch.org

Volume 19, 2020

TECHNOLOGICAL STRUCTURE FOR TECHNOLOGY INTEGRATION IN THE CLASSROOM, INSPIRED BY THE MAKER CULTURE

Juarez Bento Silva*	Federal University of Santa Catarina, Araranguá, Brazil	juarez.b.silva@ieee.org
Isabela Nardi Silva	Social Service of Industry, Criciúma, Brazil	isabela.n.silva@edu.sesisc.org.br
Simone Bilessimo	Federal University of Santa Catarina, Araranguá, Brazil	simone.bilessimo@ufsc.br

* Corresponding author

ABSTRACT

Aim/Purpose	This paper presented the framework for the integration of digital technologies in education, implemented in InTecEdu Program, developed by Remote Experimentation Laboratory (RExLab), Federal University of Santa Catarina (UFSC), Brazil.
Background	The main objective of the model presented is to arouse interest in science and technology among adolescents. Therefore, it sought to develop STEM competencies (Science, Technology, Engineering, and Mathematics) in children and adolescents. Understanding learning in STAM areas can favor the development of professionals who can supply the demand in related sectors, especially in the scientific-technological scope. To fulfill the main objective, strategies related to students and teachers were developed. With activities aimed at students, it was hoped to promote vocations to scientific-technological careers and encourage entrepreneurship. On the other hand, the activities related to teachers aimed at training them to integrate technology into their lesson plans. Inspired by the Maker Culture, the model sought to make it possible for teachers to become the main agents in the process of integrating technology in their lesson plans, since they were in charge of building and producing their digital content and other resources to support their didactic activities. The maker movement is a technological extension of the "Do It Yourself!" culture, which encourages ordinary people to build, modify, repair,

Accepting Editor Donna Jean Satterlee │Received: November 23, 2019│ Revised: February 29, March 18, April 2, 2020 │ Accepted: April 3, 2020.
Cite as: Silva, J. B., Nardi Silva, I, & Bilessimo, S. (2020). Technological structure for technology integration in the classroom, inspired by the maker culture. *Journal of Information Technology Education: Research, 19,* 167-204. https://doi.org/10.28945/4532

	and manufacture their objects, with their own hands. The training actions were preceded by a diagnosis, inspired by the Technological Pedagogical Content Knowledge (TPACK) model, as well as the lesson plans prepared and made available by the teachers.
Methodology	Methodologically, the framework's work plan was composed of five Work Packages (WP), which include management, resource mapping, strategies related to teachers, strategies related to students, and the dissemination and exploitation of results. In the 2014-2018 period, 367 teachers participated in training activities, intending to integrate technologies into lesson plans. At the end of 2018, 27 Basic Education schools, including an indigenous and a rural school, from the public-school system, in the states of Santa Catarina, Minas Gerais, and the Rio Grande do Sul, in Brazil, using the project's Virtual Learning Environment (VLE). In these 70 teachers, 230 classes, and 6,766 students accessed didactic content, produced by teachers, at VLE. Also, 20 laboratories were available in 26 instances, for use in practical activities in disciplines in the STEM areas. Specifically, in the STEM areas, 3,360 students from 98 classes from 9 schools had integrated the Remote Laboratories, in lesson plans in the subjects of Physics and Biology (High School), Science (Elementary School).
Contribution	The main results of the application of the framework are related to the training of human resources, knowledge production, and educational innovation. About the training of human resources, we sought to contribute to the training of teachers concerning technology in education and, with that, arouse greater interest on the part of students, as well as obtain improvements in their learning from teaching methodologies supported on the use of digital technologies. On the other hand, the production of knowledge, in the program and the socialization of research, is favored by the model based on open-source resources, both in terms of software and hardware and with open educational resources. This characteristic favor and expands the potential for reapplying research and, consequently, its contribution to educational innovation.
Findings	The results, about students, indicated an increase in motivation due to the creation of new teaching and learning opportunities. The fact of extending the classroom and school, through remote laboratories, to support practical activities and the use of VLE, was also pointed out as a very positive factor. On the other hand, the realization of the workshops, inspired by practices of the Maker Culture, provided an approximation of these to the skills of the real world, which will certainly favor their employability. Regarding the teachers, it is noticed the continuity and expansion in the use of technological resources in the classroom; many sought and have participated in new training actions.
Recommendations for Practitioners	Provision of a repository of practices for sharing and reuse of lesson plans developed by teachers participating in the research. Technical documents, manuals, and guides for robotics, computer programming, electronics and new technology workshops for students.
Recommendations for Researchers	Technical documents, manuals, and guides for remote laboratories. Data collected in the applied questionnaires. Technical documents, manuals, and guides for robotics, computer programming, electronics and new technology workshops for students.

Impact on Society	The main results of the framework application are related to human resources formation, knowledge production, and educational innovation. Regarding the formation of human resources, we sought to contribute to the formation of teachers concerning technology in education and, about the students the creation of teaching and learning opportunities, to extend the classroom and also the school, through the remote laboratories, to support the practical activities and the use of the VLE.
Future Research	The socialization and reapplication of the framework since it is based on open-source resources, both software and hardware, and with open educational resources.
Keywords	framework, integration, technology, teaching and learning, teacher improvement, open educational resources, virtual and remote labs

INTRODUCTION

The increasing presence of Information and Communication Technologies (ICT) in the field of education has generated great debate, demanding a stance on it; it can no longer be thought that ICTs are not relevant to education. However, even with the high speed of development of ICT, they still arouse fears, resistance, and discussions when talking about them in the educational context. It must be considered that ICT offers possibilities for teaching and, as a result, is a major challenge for the educational system. Educators should use open and flexible teaching models, where information tends to be shared in a network and focused on students.

This document presents the framework for the integration of digital technologies in basic education, implemented in the Program of Integration of Technology in Education (InTecEdu). Such a structure relies on open educational resources, free software and open hardware, and virtual and remote laboratories for practice in the STEM areas (an acronym for Science, Technology, Engineering, and Mathematics), thus seeking to stimulate their reapplication.

The construction of the framework proposes strategies that seek to address the four guiding assumptions of the InTecEdu Program:

1. The need for more attractive environments for teaching and learning in basic education;
2. The growing use of mobile devices and the Internet by children and adolescents;
3. The need for teacher training for the use of ICT in pedagogical practice; and,
4. The lack of infrastructure, especially in Brazilian public schools.

According to the document Synopsis of Higher Education Statistics 2018 (Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira [INEP], 2019a), in 2018 Brazil had 8,450,755 students enrolled in Higher Education. In the same period, according to the 2018 Brazilian School Census (INEP, 2019b), it had 48,366,347 students enrolled in Basic Education (82.55% in the public education network), of which 27,183,970 are in Elementary Education (82, 81% in public schools) and 7,709,929 are in High School (87,91% in public schools). It is perceived that the transition between educational levels is very deficient, causing a great "bottleneck" in the passage from Elementary School to High School, impacting the entrance of students in Higher Education and, consequently, in different areas of training. The number of graduates in Higher Education in 2018 was 1,004,986 if we take into account the number of new students in 2014, 7,828,013 (INEP, 2019a). And considering the average duration of courses in 4 years, we could estimate a success rate in higher education training of 12.83%. The situation is even more aggravated when the data on freshmen and graduates in the scientific and technological areas are checked. According to the same document (INEP, 2019a), of those enrolled in Higher Education in 2018, 1.42% were in the area of Natural Sciences, Mathematics, and Statistics, 3.95% in Computing and ICT, and 13.85% in Engineering, Production, and

Construction. Regarding graduates in the period, 1.26% in Natural Sciences, Mathematics, and Statistics, 3.45% in Computing and ICT, and 12.92% in Engineering, Production, and Construction. (INEP, 2019a)

The failure and/or dropout rates were 6.0%, 12.9%, and 16.9%, respectively for Elementary School I, Elementary School II, and High School (INEP, 2019c). The 9th grade of elementary school had a dropout rate of 7.7%. These are significant percentages if we take into account that in 2017 Brazil had over 35 million students enrolled in elementary and high school. In addition to the indexes presented, the account should also be taken of the dropout in the transition from the 9th grade of elementary school to the 1st grade of high school. In this phase, the transition from Elementary School to High School, many young people, especially if they are low income, are tempted to drop out of school and focus their efforts on entering the job market.

Employability is a factor, however, several other causes cause evasion, and these will not be addressed in this document. However, the concepts of meaning, flexibility, and perception also represent factors that contribute to this. Many adolescents and young people have the feeling that the school is not adequate to their reality and vision of the future and start to consider it "as a waste of time and end up preferring to dedicate themselves to other things" (Meaning). They do not perceive the school as flexible or innovative if they engage less in school activities (Flexibility). The perception of importance, on the other hand, emphasizes that education and school must not only teach relevant topics but also motivate students and show that what the object of study is or will be useful for their life, that is, presenting education as a value.

In this context, there is a reinforced need for more attractive environments for teaching and learning, to redesign education, creating new and interesting teaching and learning opportunities. The integration of digital technologies in the educational context may provide the opportunity to create a compatible environment, not antagonistic, with the way people learn, especially children and teenagers.

Digital technology changes at breakneck speed at a constantly accelerating pace. They are currently an integral part of the society we live in and have impacted people's way of life. Devices such as smartphones, notebooks, and a plethora of gadgets and computing devices surround our activities and will inevitably reach the educational realm. Their insertion in the educational context can redesign education and create new and interesting teaching and learning opportunities in addition to extending not only the classroom but also the school. The school should not limit the teaching and learning processes to the time and space of the class. In a concept of ubiquity (Cope & Kalantizs, 2009) referring to a society that learns and absorbs data and information all the time and everywhere, directly influencing how teaching and learning are done should be viewed in this context. According to the CoSN Driving K – 12 Innovation / 2019 Tech Enablers report (Consortium for School Networking, 2019) the key technology tools with the potential to ease the way for broader educational opportunities and solutions are mobile devices, learning analysis and adaptive technologies, blended learning, extended reality, and cloud computing infrastructure. Estimated adoption by schools worldwide on a scale of 1 to 5 (1 = most immediate adoption; 5 = furthest from adoption) was thus estimated:

- 1.26: Mobile Devices;
- 1.41: Blended Learning;
- 1.58: Cloud Infrastructure;
- 2.48: Extended Reality;
- 2.49: Analysis and adaptive technologies.

Mobile devices, such as smartphones, allow you to access creative information and activities anytime, anywhere. Mobile devices also support global connections, auto-capture content, and personalize learning. They are devices with the potential to provide learning opportunities and to fill even the gaps in infrastructure shortages.

Data from the National Telecommunications Agency (Agência Nacional de Telecomunicações [Anatel], 2019) indicate that Brazil ended 2019 with 229.2 million cellular and density of 109.24 cellular/100 inhab. Regarding the use of these devices, data from the Teleco Inteligência em Comunicações portal (Teleco, 2019), for 2018, identified the following profiles:

- Percentage of people in the age group who accessed the Internet in the 90 days preceding the survey.
  - 10 to 15 years: 91%
  - 16 to 24 years old: 96%
- Internet Users by Income Range:
  - Less than 1 Minimum Wage (SM - Minimum wage, or Salário Mínimo (SM) is the lowest monetary payment, defined by law, that a worker must receive in a company for his services in Brazil. According to Decree No. 9,661 of January 1, 2019, the minimum monthly wage in Brazil in 2019, the minimum monthly wage in Brazil in 2018 is R $ 998.00 (nine hundred and ninety-eight Reais). Performing the currency conversion, on the date of publication, to the US $ (the US $ 1 = the US $ 3,874), on 01/01/2019, the value obtained would be the US $ 257.61.): 60%
  - 1SM - 2SM: 72%
  - 2 SM - 3 SM: 79%
- The location used for access by Internet users:
  - At home: 94%
  - At school: 19%
  - Workplace: 19%
  - In someone else's house: 62%

The data presented points to opportunities for mobile devices, especially smartphones, in the Brazilian educational context.

However, educational innovation necessarily involves the need for training teachers to integrate technology into pedagogical practice. The integration of technology in the classroom involves specific skills of teachers concerning their pedagogical use. For the integration of technologies in classes to be more effective, it will be necessary for teachers to have the relevant skills, to be able to develop them and to incorporate them into their daily tasks. This implies that the teacher must know them in their dimensions, be able to critically analyze them, and make an appropriate selection of both the technological resources and the information they convey, and they must be able to use them and implement an appropriate integrated curriculum in the classroom. It is then possible to state that the technologies affect the teacher, insofar as they require training for their use. Teachers need to have an open and flexible attitude towards the continuous changes that occur in society as a result of technological advancement. It turns out that there is a significant gap between technology and pedagogy, as shown in the following data: "TIC Educação 2018", conducted by the Brazilian Internet Steering Committee (CGI.br; 2019). The research was carried out, between August and December 2018, in urban schools: public (except federal) and private schools with classes of 5th or 9th grade of Elementary School or 2nd year of High School. 1,807 Portuguese and Mathematics teachers participated. It indicated, among others, that:

- 55% did not take any class on the use of computers and the Internet in teaching activities during their undergraduate course;
- 70% did not participate in a post-graduation course on the use of computers and the internet in teaching activities;
- 90% of the teachers, when asked about how to learn and update about the use of the computer and the internet, answered "alone".

The data presented above indicate deficiencies in the training of teachers about the pedagogical use of ICT. These shortcomings will constitute barriers to the integration of ICT in their lesson plans. In this sense, the research "ICT Education 2018" (Brazilian Internet Steering Committee, 2019), on the barriers perceived by teachers of urban schools, for the use of ICT in schools, pointed out that:

- 84% stated that the absence of a specific course for the use of computers and the Internet in classes made it difficult to use technology in their classes.
- 68% of teachers pointed out that the "lack of pedagogical support to teachers for the use of computers and the Internet" was a barrier to the use of ICT in the classroom;
- 69% responded that they did not publish resources produced through ICT for their students;
- 77% of respondents indicated that a barrier to publishing resources on the internet is the lack of knowledge about where to publish and 66% do not publish due to "lack of interest".

The lack of adequate skills in the use of ICT makes many teachers resort to traditional models of teaching, neglecting the use of technologies. Unquestionably, the integration of ICT in the classroom depends upon teachers' specific competencies regarding the pedagogical use of these technologies. For the integration of technologies into classes to be more effective, teachers need the skills to develop them and incorporate them into their daily tasks. Despite the formative needs of teachers about the pedagogical use of ICTs, the lack of infrastructure in schools of basic education, especially in the Brazilian public network, should also be highlighted. Of the teachers questioned in the ICT Education 2018 survey about perceived barriers to using ICT in class (INEP, 2019b):

- 83% pointed out the insufficient number of computers connected to the Internet;
- 85% indicated "slow internet connection;"
- 83% referred to the insufficient number of computers for student use.

Corroborating the perception of teachers interviewed in the research ICT Education 2018. Some data from the School Census of Basic Education MEC/INEP 2018 (INEP, 2019b) are presented, which pointed out:

- - 38% of schools (38% public schools [PUS]); 37% private schools [PRIS]) had a computer lab;
- - average of 7.41 computers per school for student use (6.7 PUS and 9.7 PRIS);
- - Regarding broadband Internet access, 61% of schools had this resource (54% PUS and 86% PRIS).

Also, concerning the lack of infrastructure of basic education schools in Brazil, it is important to highlight the availability of science laboratories to support the disciplines in the STEM areas. According to the MEC/INEP 2018 School Census of Basic Education (INEP, 2019b), only 11% of schools in Brazil (8% public and 19% private) had science laboratories.

This paper presents a framework for the integration of technologies in Basic Education, developed and applied by the Remote Experimentation Laboratory (RExLab - rexlab.ufsc.br) of the Federal University of Santa Catarina (UFSC), in Araranguá/SC, Brazil. Inspired by the Maker Culture, the model sought to allow teachers of basic education to be the protagonists of the integration of technology in their lesson plans. In the model presented, they are in charge of building and producing their digital content and other resources to support their teaching activities, against the backdrop of the promotion of initiatives and examples to stimulate the scientific and technological vocations of Basic Education students, providing improvements in their learning based on teaching methodologies supported by the use of digital technologies. Aiming to provide support for the length of the objectives, methodologically the work plan of the framework was composed of five Work Packages (WP) so named WP.1 - Project Management; WP.2- Provision of resources and infrastructure for program development; WP.3 - Strategies related to teachers; WP.4 - Strategies related to students; and WP.5 - Dissemination and exploitation of results. These WPs will be covered in more detail in the section dealing with the methodology.

However, it should be noted that strategies related to teachers included an initial diagnosis, which sought their perception related to their knowledge (technological, pedagogical, and disciplinary / content) and how they integrated technology in their classrooms. It aimed to know the degree of training and use of ICT in a class by the teachers. This initial diagnosis provided the acquisition of insights, which contributed to the conduct of the specifications and requirements of the teaching resources that were chosen and implemented in the lesson plans. Although several models related to the integration of technology in the teaching and learning processes are found in the literature, the option for the research carried out fell on the TPACK (Technological Pedagogical Content Knowledge), as it is the model that the InTecEdu Program has been looking to develop since 2011. After the initial diagnosis, the training was formalized through courses, short courses, workshops, lectures, and events that address themes and case studies regarding the integration of technology in education. The integration of technology was focused on providing a collaborative environment for the construction of lesson plans, and it was supported by didactic content open online, available in the Virtual Teaching and Learning Environment (VLE), which was customized and made available by RExLab. In addition to the VLE, teachers also used the prototyping and manufacturing laboratory to build various artifacts for use in class, as well as using virtual and remote laboratories to support practical activities, especially in the STEM areas.

The strategies related to students seeking to create teaching and learning opportunities, using mobile devices, to extend the classroom and also the school. To support the practical activities of the disciplines, remote laboratories were made available, in addition to the use of VLE. They included workshops, inspired by practices of the Maker Culture, which aimed to provide teenagers with real-world skills. These skills can favor their employability. Inserting students in this context, their engagement is expected to motivate them to complete their school career, as well as to promote vocations to scientific-technological careers and encourage entrepreneurship. The production of knowledge in the program is related to the socialization of research and educational innovation occurs, in large part, due to the potential for reapplying research. Research is based on open-source resources, both at the software and hardware levels and with open educational resources.

THEORETICAL BACKGROUND

TECHNO-EDUCATIONAL MODELS

Figure 1 summarizes the main actions developed, related to the strategy directed to teachers, which are contemplated in WP.3. The activities in this WP are divided into four groups: TPACK Model, Training, Available resources, and Formalization of the framework. TPACK Model is related to the educational model and the other three are due to the application of the model. Thus, we will address the topic of the educational models below.

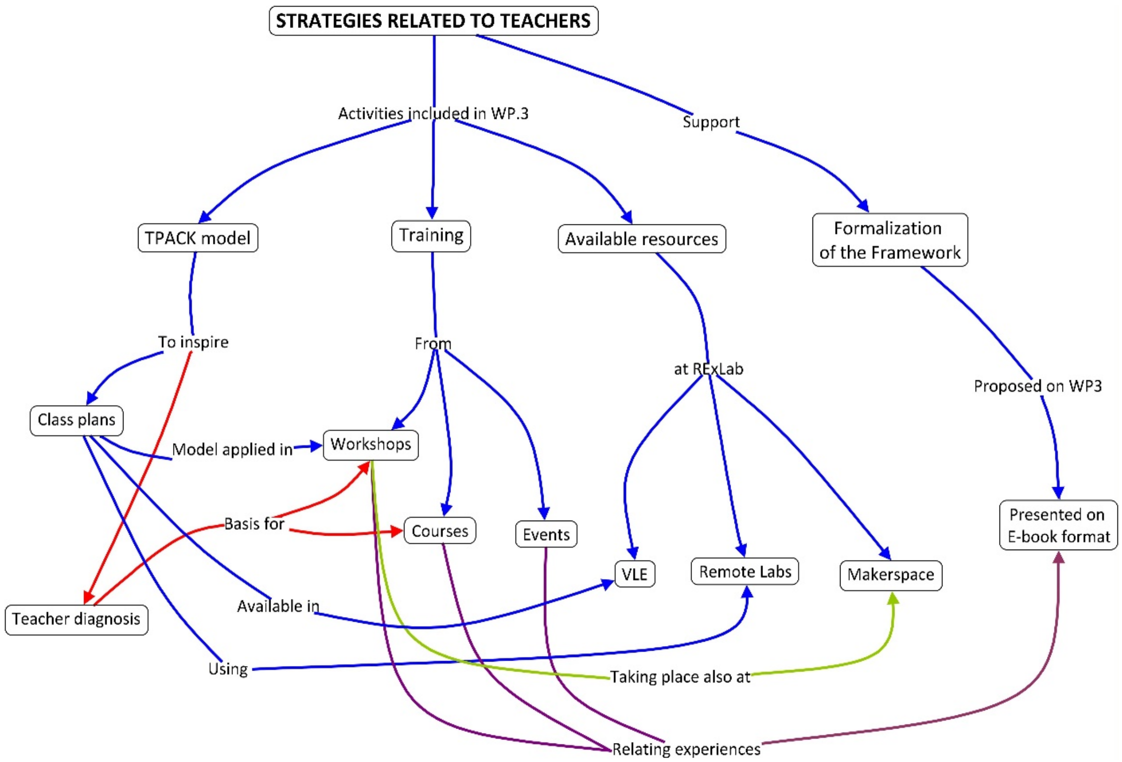

Figure 1. Strategies related to teachers

The inclusion of technologies in education is not always homogeneous. While in some institutions it is received with enthusiasm, in others it is received with uncertainty, although there is consensus on the importance of its integration in the teaching and learning processes. The literature presents many models for the integration of ICT (Information and Communication Technologies) in education, models that seek to reach the didactic level of ICT and that are related to different moments in the use of these in educational processes. Among the various models cited in the literature can be included "models oriented to instructional design or distance education" and "models oriented to the development of environments". The first models are those that seek to define the instructional process as a system and present a variety of actions or related steps aimed at the development of an ordered and compact educational process. The models of the second group can be identified as those aimed at the development of learning environments directed to specific uses.

Regarding the models oriented to instructional design or distance education, the following can be presented:

- ADDIE (Analysis, Design, Development, Implementation, and Evaluation). The model was developed in the mid-1970s by Florida State University. According to Branch (2009), ADDIE adopts the paradigm of information processing and the theory of the human knowledge system. This model has also served as a development base for other instructional design models, as it presents a "general structure".
- ARCS (Attention, Relevance, Confidence, and Satisfaction). Developed and presented by John M. Keller in 1987, this model is based on the idea that there are characteristics, personal, and environmental factors that influence motivation and, therefore, performance in educational tasks.
- ASSURE (Analyze, State, Select, Utilize, Require e Evaluation). It was created by Heinich, Molenda, Russell, and Smaldino in 1999. The basis of this model draws on three theories: that of Gagné, which focuses on the conditions that intervene in learning, as well as the be-

haviors that result after generating learning; the constructivist, since it resumes the importance of generating new knowledge and feedback from the interaction with previous knowledge; and the connectivist theory of George Siemens (2004), which refers to the ability to build knowledge from the use of (ICT)) and collaborative work through networks.

- HyFlex. Developed by Brian Beatty, who presented the model in 2006. The name of the model, composed of the words Hybrid and Flexible, gives a general idea of what the author proposes: providing the student with virtual and in-person learning experiences in a flexible way. Flexibility is implicit both in the way of presenting the content and in the activities themselves, among which the student can do everything or choose between equivalent options. In essence, students create a mix of participation, adjusting it to their needs and desires. HyFlex's design emphasizes student-centered teaching (Beatty, 2006).
- The Dick and Carey Systems Approach Model". Dick and Carey's model for the design of courses, programs and teaching materials for teaching and learning originated in 1978 when authors Walter Dick and Lou Carey proposed it as a model for distance learning (Dick & Carey, 2001). According to Dick and Carey (2001), this model seeks to optimize instruction, the educational process or teaching through the training of the instructor. It is focused on strategies for instructors to acquire more knowledge, learn more methods and be able to apply them to their students. (Gámez, 2015; Robin & McNeil, 2012).

Regarding models oriented to the development of environments, we highlight:

- ACOT (Apple Classrooms for Tomorrow). It was launched in 1985 and emerged as a collaboration and research project between public elementary schools, universities, and research agencies, with the support of Apple Computer, Inc. In summary, it can be said that ACOT proposed the use of technology by teachers and students as a factor of change in the teaching and learning processes. (Apple, 2008)
- COI (The Community of Inquiry). Developed by Garrison, Anderson, and Archer (2000), this model conceptualizes the creation of a virtual learning community, based on constructivism and collaboration, in which its members learn from three interdependent elements: social presence, teacher presence, and cognitive presence.
- ITL LOGIC (Innovative Teaching and Learning Logic Model). The ITL was developed by the Stanford Research Institute (SRI) in 2009 and seeks to generate basic education student's new life and work skills, based on a perspective of changing national policies, a change in school leadership and cultures, which will be reflected in innovative educational practices. (Gámez, 2015)
- TIM (Technology Integration Matrix). This technical-pedagogical model was developed by Jonassen, Howland, Moore, and Marra (2003) and adapted by the Florida Center for Educational Technology, University of South Florida College of Education; in 2011. TIM is characterized by its application dealing with personal computers, mobile devices, and technological resources for educational use. The tools provided by ICT allow education, space, location, and time to adapt to users. (Gámez, 2015; Lage, Platt & Treglia, 2000; Talbert, 2012; Tolu & Evans, 2013)

And finally, "models that favor the use of various technological resources", which are of greatest interest to the research carried out. These are models that address the use of different technological resources or means. In this group the models can be mentioned: CONNECT, CLEs, FSM, OILM, SAMR e TPACK (Gámez, 2015).

- The CONNECT model suggests that learning contexts and methods should be mixed. It defines the use of the contextual learning model, where the importance of students' personal, physical, and socio-cultural contexts is fundamental; specifically, it defines the role of free choice of the type of learning. The model originated from the CONNECT Project, which was co-financed by the European Commission under the IST - Information Society Technologies program (Sotiriou et al., 2006), whose objective was to implement the activities proposed in schools by teachers and educators, originally conceived under the concept that informal learning is obtained in museums and science parks (Gámez, 2015).

- The model *Constructivist Learning Environments* (CLEs) was developed by David Jonassen in 1999 and its main objective is to promote problem-solving and conceptual development, as well as emphasizing the student's role in building knowledge (learning by doing). CLEs use instructional design as a model to design environments that involve students in the development of knowledge through the implementation of the elements that constitute it (Jonassen, 1999).
- The FSM (Five-Stage Model of E-learning) was developed by Gilly Salmon in 2000 and consists of five stages or phases to develop learning in a virtual mode with the help of a moderator. Its scheme represents a ladder on which each step expresses the academic, technical, and moderation skills involved in learning and teaching in a virtual community, where they are all related to each other through the interaction between their elements. The theoretical basis of the model consists of Vygotsky's Next Development Zone, Constructivism, and Cooperative Learning (Abdullah, Hussin, Asra & Zakaria, 2013; Gámez, 2015).
- The Online Interaction Learning Model (from the English Online Interaction Learning Model, or OILM) was proposed by Benbunan-Fich, Hiltz, and Harasim, in 2005. This model has been applied as a theoretical reference for online courses and as a techno-pedagogical model in university education. The model is based on the constructivist theory of learning, which promotes the practice, discovery, and validation of knowledge by the student (Benbunan-Fich, Hiltz, Starr & Harasim, 2005). Promoting the combination of student participation with interpersonal group processes, the authors of the model claim that these interactions are related to the extent that collaborative learning pedagogy is used.
- The Substitution, Increase, Modification and Redefinition (SAMR) model was developed by Rubén Puentedura and presented for the first time at the MERLOT4 International Conference (Puentedura, 2003). SAMR consists of a hierarchical set of 4 levels that allows assessing the way technologies are used by teachers and students in a class. Its goal is to help teachers assess how they are incorporating technology in their classrooms and, thus, knowing what type of technology use has a greater or lesser effect on student learning (Puentedura, 2012). Figure 2 shows the four levels that make up the SAMR model. It can be seen that the first two levels imply technological improvement and the last two involve technological transformation.

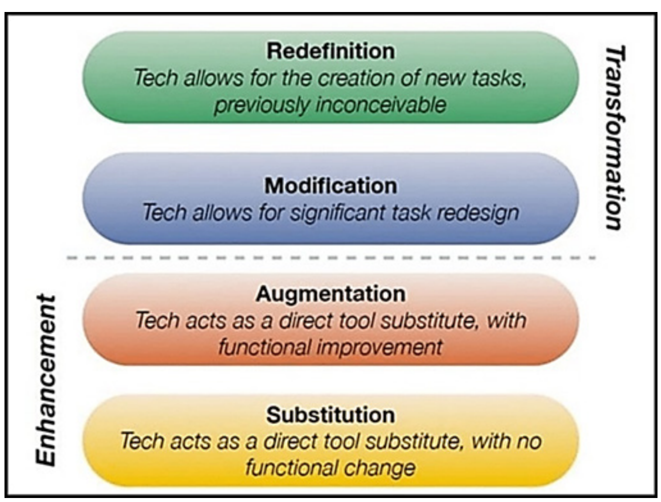

Figure 2. SAMR model
Based on Puentedura (2012)

- And we finish with the TPACK (Technological Pedagogical Content Knowledge) model. This model was developed between 2006 and 2009 by professors Punya Mishra and Matthew J. Koehler of Michigan State University. The proposal has its initial foundations in the PCK approach developed by Shulman (1986) and to which was added the term "Technology" (T), to the already existing "Pedagogy" (P) and "Curricular Content" (C). Taking into account the contributions of Koehler and Mishra (2008) for effective teaching practice and conversations about good practices, they must be based on three basic components: Curricular content (CK - Content Knowledge), Pedagogy (PK - Pedagogical Knowledge), and Technology (TK - Technological Knowledge) and all the interactions established between these components. The interactions between these components (CK, PK, and TK) are the basis of the TPCK model.

The authors Koehler and Mishra (2009) state that the three areas of knowledge must be interrelated: Content (CK) located in the area of knowledge, subject, or content taught and learned, according to Mishra and Koehler (2006) "is knowledge about the subject to be taught or learned;" pedagogical knowledge (PK) for teaching and learning processes, general objectives, values and goals for education; whereas, the Technology knowledge (TK) focused on the assimilation of how to apply ICTs at work and daily life. This knowledge has its origins in the fields of Pedagogy, Didactics, and others, being what is applied in student learning. Technological Knowledge (TK) covers traditional technologies or digital technologies. (Mishra & Koehler, 2006)

The intersection of the three types of knowledge covered (CK, PK, and TK) will give rise to four new types of knowledge, which are the following: Knowledge of pedagogical content (PCK); technological content knowledge (TCK); Technological Pedagogical Knowledge (TPK); and the Technological Pedagogical Content Knowledge (TPACK), where the teacher's knowledge is linked and evaluates his competences to be able to transmit a certain discipline, all with a significant approach related to the context of interaction (Koehler & Mishra, 2009). Figure 3 identifies the three sets of knowledge that interact with each other and between the three, constituting new types of knowledge.

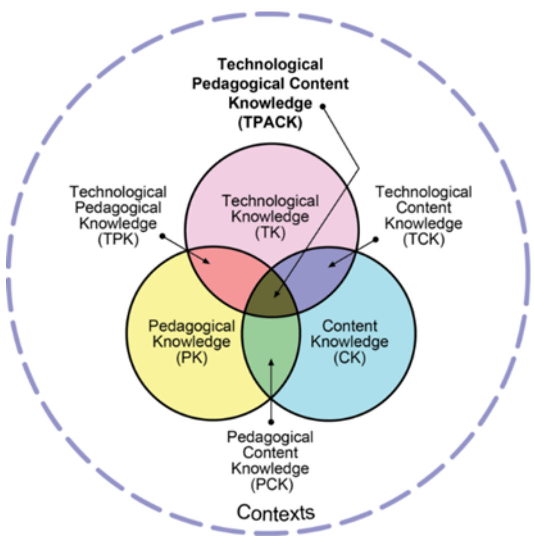

Figure 3. TPACK Model
Based on http://www.tpack.org/

TPACK is a model that seeks to identify the types of knowledge that teachers need to master to integrate ICT effectively in the teaching they transmit. Its main objective is the articulation of the three types of knowledge that form its base (CK, PK, and TK), to be successful in teaching and learning objectives.

Thus, it is a pedagogical model in which the teacher can use certain actions that can be supported in the use of technologies in education. However, despite proposing the integration of ICT in schools, the current results, as previously pointed out, demand new questions and the need to consider how the programs of application of TPACK could better support the pedagogical practices of teachers (Koh, 2019).

According to Harris, Mishra, and Koehler (2009), teachers must try to understand the domains of TPACK, their contexts, and their correlations. It should be noted that there is no single or magical technological solution that will work in all contexts (teacher, course, or pedagogical approach). The success in integrating technology in the educational field is directly related to flexibility and the ability to travel through the fields of content, pedagogical, and technological knowledge, as well as the interactions between them. Ignoring the complexity inherent in each component of knowledge or its relationships will inevitably lead to the failure of the initiative.

It is essential that teachers develop fluency in the main domains (content, technology, and pedagogy) and not just in one or part of them. By being able to understand how these domains are interrelated, teachers will be expanding the possibilities of success. For example, TPACK considers that technical knowledge is essential for teaching and learning, however, this is not enough to promote changes in the ways of teaching and learning, since other knowledge is needed by teachers. For teachers who choose to teach and learning mediated mainly by digital technologies, they should consider the integration and overlap of the domains and subdomains of TPACK, working them in unity. (Harris et al. 2009)

Despite the characteristics of the different models that favor the use of different technological resources addressed, in the research presented here the model chosen was TPACK, as it is the model chosen by the InTecEdu Program execution team, which since 2011 has been trying to develop the TPACK framework in the program. The team's motivation for choosing TPACK is due to the basic premise behind its concept. Koeller & Mishra (2008) understand that the attitude of a teacher, about technologies, is multifaceted and that an optimal combination for the integration of ICT in the curriculum results from a balanced mix of knowledge at the scientific or content level, at a pedagogical level, and the technological level.

MAKER CULTURE

The Maker Culture aligns with the concepts of constructivism and has its origin in the post-war 1950s and refers to the "Do it yourself" (DIY) culture. The DIY culture became popular in the past decade, mainly with the launch of the American magazine Make in early 2005; the Maker Faire exposition promoted by the magazine. The Maker Culture emphasizes learning-through-doing (active learning), informal learning, interaction with the community, networking, and knowledge sharing. It is a social movement with an artisanal spirit, in which digital manufacturing methods, which previously were the exclusive domain of institutions, have become accessible on a personal scale. This is due to the popularization of personal computers, which started in the 1970s, and the access to resources such as 3D printers, laser cutting machines, vinyl cutting machines, open and easy to program software and hardware systems, for example, Arduino (Sharples et al., 2014; Swan, 2014).

Due to the availability of resources, the Maker Culture started to attract the interest of educators concerned mainly with students' lack of interest and motivation for courses and disciplines in the STEM areas (science, technology, engineering, and mathematics). Thus, the Maker Culture came to be seen as having potential for use in formal educational environments and as having the potential to contribute to a more participatory approach and the creation of new teaching and learning methodologies, to motivate students (Anderson, 2013).

One of the basic premises of the InTecEdu Program is the need to provide more attractive environments for teaching and learning in basic education to improve the acquisition of technical and scientific skills and, therefore, the medium- and long-term results of students in the STEM disciplines. To this end, it is essential to provide them with access to innovative methodologies and resources, such as open-source software and hardware, projects based on research, and the use of programming languages, and from these resources encourage experimental work (hands-on), within a maker perspective.

The strategy related to students, presented in work package 4, was designed to foster scientific culture and scientific dissemination in Basic Education. It assumes as a fundamental premise that the incentive to a scientific culture in basic education schools, mainly in the public network, must pass through the provision of resources (human and material) that can create a favorable environment for their development. In this sense, the implemented framework seeks to provide students with access to digital content and other resources to support their teaching activities, in addition to providing extension activities, such as workshops, courses, events, and activities of scientific and technological nature, which aimed to motivate them. Figure 4 summarizes the main actions of this WP.

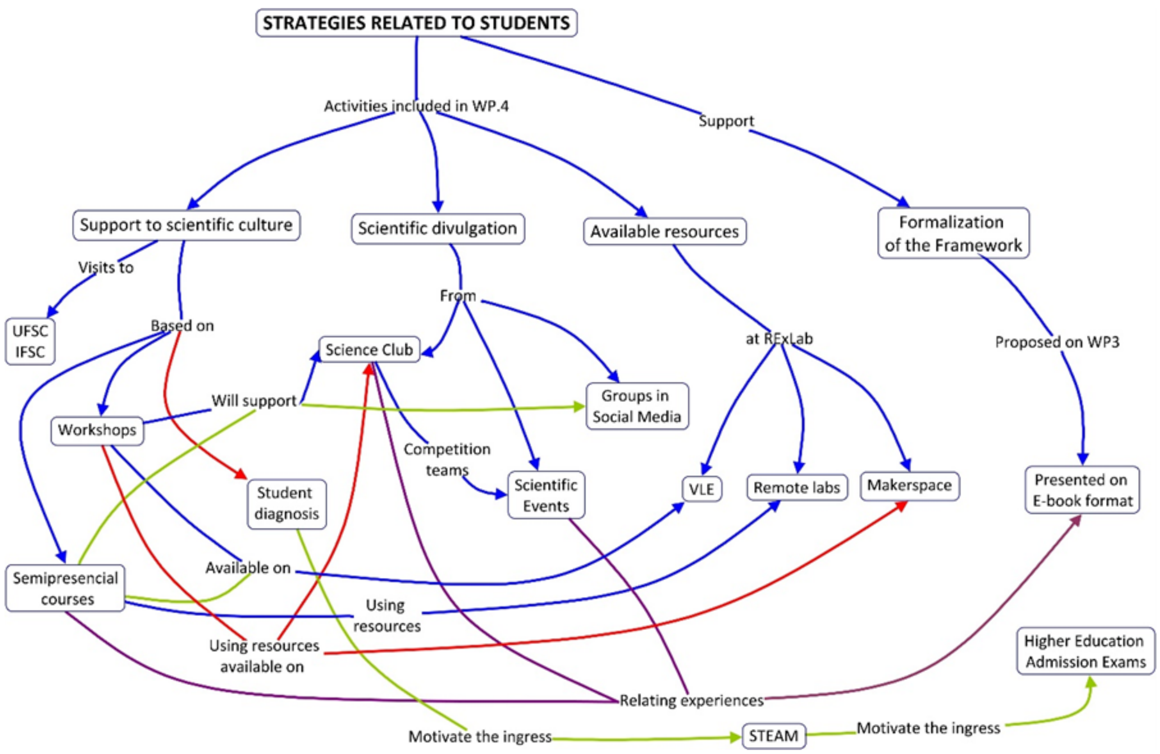

Figure 4. Strategies related to students

Scientific training, in the opinion of many experts, is a requirement that has been demonstrating its strategic role in the development of people and peoples. Scientific training or culture must be acquired from the first years of schooling and, mainly, before dropping out, since, in many countries, such as Brazil, there are high rates of dismissal before the completion of high school. It is observed that the deficit in science education goes far beyond the fact of learning or not learning the scientific contents. This deficit will also hinder the full exercise of that person's citizenship. Another side of the same problem is poor science education because it also fails to increase interest and motivation for learning science. If this situation persists, students will not be attracted to scientific and technological careers. It is necessary to motivate the acquiring of scientific knowledge; only then each country will have an increased number of highly skilled scientists to contribute to innovation and development.

The lack of interest, and even the rejection to study the sciences, associated with the failure and school dropout of a high percentage of students, constitute a problem that has a special gravity, not only in Brazil but worldwide. As discussed at the World Conference on Science for the 21st century, promoted by the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the International Council for Science, "so that a country is in a position to meet the fundamental needs of its population, science, and technology education is a strategic imperative" (Declaration on science and the use of scientific knowledge, 1999).

Current data from the International Student Assessment Program (PISA), published in December 2019 by the Organization for Economic Co-operation and Development (OECD, 2019), indicate that in Brazil, 45% of students are at level 2 or above and 55% are below level 2 in science, a level that the OECD establishes as basic so that young people have the skills to identify an adequate scientific explanation and a simple experimental project based on their previous knowledge acquired from their daily experience. It is also said that 4.38% of Brazilian students were below the lowest level that the OECD determines expected skills for science students.

This difference between proficiency below level 2 and proficiency equal to or higher than that level corresponds, according to the OECD, to a qualitative distinction between being able to apply limited scientific knowledge only in known contexts (i.e., knowledge " common ") and demonstrate at least a minimum level of autonomous reasoning for understanding the basic characteristics of science, which allows students to engage with science-related issues as critical and informed citizens. These data reveal that Brazilian students are unable to associate school knowledge and everyday life. Despite being able to explain the phenomena scientifically, they are unable to interpret scientific data and evidence, showing that they did not appropriate what they studied (OECD, 2019).

In the context of scientific and technological education, students should learn to solve real problems and meet the needs of society, using their scientific and technological skills and knowledge. The authors Hodson and Reid (1998) propose that an education directed towards a basic scientific culture should contain:

- Knowledge of science, certain facts, concepts, and theories;
- Applications of scientific knowledge, the use of this knowledge in real and simulated situations;
- Problem-solving, application of skills, tactics and scientific knowledge in real contexts;
- Interaction with technology, solving practical problems, with scientific, aesthetic, economic, social and utilitarian aspects of possible solutions;
- Socio-economic-political and ethical-moral issues in science and technology;
- History and development of science and technology;
- Study of the nature of science and scientific practice, philosophical and sociological considerations centered on scientific methods, the role, and state of scientific theory and the activities of the scientific community.

If we assume that fostering scientific culture involves educational innovation and that quality education involves the need to learn and deal with science and technology, we must think and carry out actions that can promote the integration of technology and experimentation in the lesson plans and develop strategies, aiming to foster a scientific culture among adolescents attending Basic Education.

This context is favorable to the integration of the Maker Culture in the educational environment, as this provides the integration and use of digital technologies with actions that enable the development and construction of innovative artifacts, foster creativity, and information sharing. Thus, this was the guiding factor for strategies related to students.

Materials and Methods

Seeking to be efficient to support the two main pillars of the program, the training that aims to educate teachers concerning digital technologies and the other that seeks to provide the integration of digital technologies in their lesson plans of other didactic activities, methodologically it was thought to group the activities developed from five "work packages" (WP), defined according to the required actions.

- WP.1 Program Management;
- WP.2 Provision of resources and infrastructure for program development;
- WP.3 Strategies related to teachers;
- WP.4 Strategies related to students;
- WP.5 Dissemination and exploitation of results.

Figure 5 presents a functional macro view of the proposed framework.

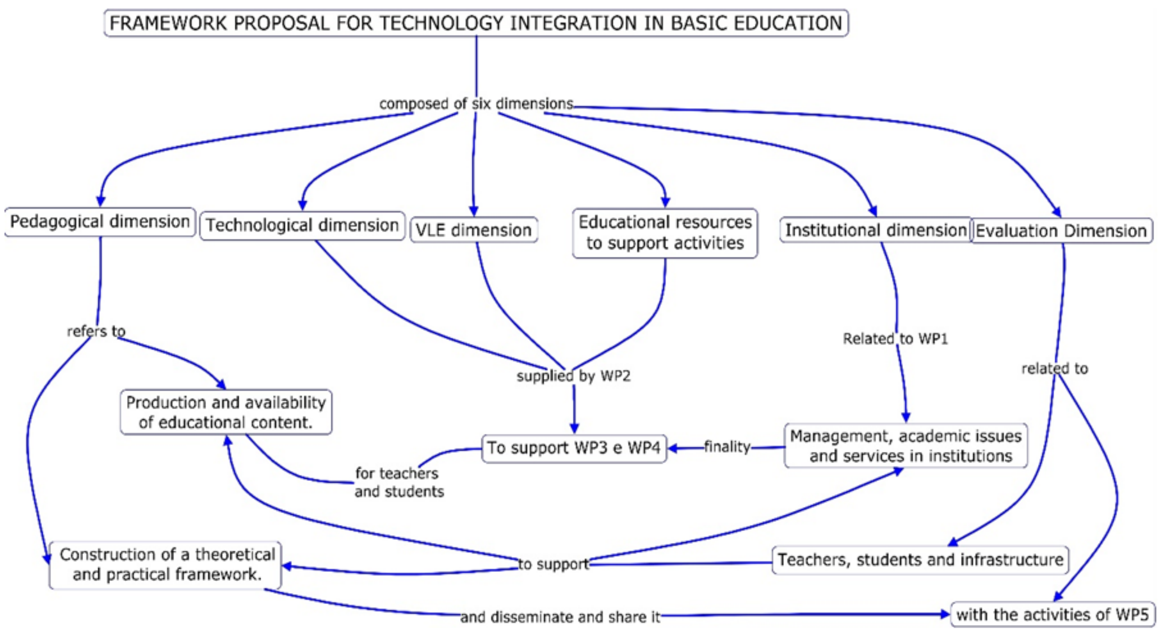

Figure 5. Framework macro view

WP.1: Program Management

The actions and activities related to WP.1 were intended to ensure the effective execution of project activities, both scientifically and administratively, and to be within the established budget and schedule. Management covered the administrative, financial, and scientific coordination of the project, including the flow of information between partner institutions and between project participants and a Steering Committee. This committee was formed by the coordinator and one representative from each participating school institution to evaluate project development. It was also part of this WP to establish channels of cooperation with other projects. Resource prospecting is a key activity when it comes to scalability and sustainability. WP.1 was also linked to the management of legal aspects of educational content created by the project and related ethical issues.

WP.2: Provision of Resources and Infrastructure for Program Development

Objectively WP.2 was related to the provision of infrastructure and resources for the framework application. Resources may originate from the participating school, the Project Executor/General Coordinator (RExLab), or through funding institutions. Initially, an inventory of existing technological resources was carried out in the beneficiary HEIs and RExLab, and their possibilities and potentials were evaluated for inclusion in the project. The provision is also associated with the continued exploration of resources and technologies, available in an open-source format, on the Internet, educational institutions and partner projects, with potential and availability for use. To this end, activities were envisaged that sought to assess the specifications of digital resource requirements (hardware, software, open educational resources, etc.) and infrastructure that can be integrated or support the framework. These specifications also include a breakdown of all available resources and the support material produced.

WP.3: Teacher-related Strategies

WP.3 focused on the design of formative actions, aimed primarily at teachers from participating schools. Actions were developed that provide the acquisition of competence that allowed them to offer their students learning opportunities supported by technology. The training actions of the teachers were preceded by an initial diagnosis that sought their perception related to their knowledge: technological, pedagogical and content, and how they think about the integration of technology in their classrooms. From this initial diagnosis, insights were obtained to guide the specifications and requirements of the didactic resources that were implemented in the lesson plans.

Instruments used in WP.3

The "Teacher Profile" questionnaire consisted of 20 questions that sought to characterize the profile of teachers participating in the program (see Appendix A). The "TPACK Questionnaire" (technological pedagogical content knowledge) (see Appendix B) aimed to investigate teachers' perceptions of technology integration in their classes. Diagnostic instruments, based on the TPACK model, have been widely used and there is a great diversity of models. The applied questionnaire was constructed based on the research entitled "Survey of Teachers Knowledge of Teaching and Technology" prepared by Denise Schmidt et al. (2009), which is composed of 54 self-report items of teacher measurement, regarding teachers' perceptions about teaching and technology. The questionnaire was adapted and validated in the InTecEdu Program, containing 50 items elaborated from a review of Schmidt's model and rewritten for the reality of the present program. The 50 items were arranged on a five-point Likert scale (see Table 1) ranging from total disagreement (1) to total agreement (5), to assess the extent to which participants agree or disagree with the statements about their beliefs about the relationship between technology and education.

Table 1. The scale of numeric values with scores

Totally Disagree (TD)	Partially Disagree (PD)	No Opinion (NO)	Partially Agree (PA)	Totally Agree (TA)
1	2	3	4	5

After application, the data obtained from the questionnaires were categorized according to the TPACK domains. Thus the 50 items were distributed and categorized into the following subscales:

- Pedagogical Knowledge (PK), 9 items;
- Content Knowledge (CK), 5 items;
- Knowledge of Technology (TK), 7 items;
- Pedagogical Content Knowledge (PCK), 7 items;
- Knowledge of Technological Content (TCK), 6 items;
- Technological Pedagogical Knowledge (TPK), 8 items; and,
- Pedagogical Knowledge of Technological Content (TPACK), 7 items.

To estimate the reliability of the questionnaires applied in the research, Cronbach's alpha coefficient was used. This coefficient was introduced by Lee J. Cronbach in 1951. The alpha measures the correlation between answers in a questionnaire by analyzing the profile of the answers given by respondents. This is an average correlation between questions (Matthiensen, 2011). The internal consistency method, based on Cronbach's alpha, allows the estimation of the reliability of a measuring instrument through a set of items that are expected to measure the same construct or theoretical dimension. Table 2 presents the acceptable values by range for internal consistency verification (Landis & Koch, (1977).

Table 2. Internal consistency of the questionnaire according to alpha value

Alpha coefficient value	Internal Consistency
0,81 – 1,00	Almost perfect
0,61 - 0,80	Substantial
0,41 – 0,60	Moderate
0,21 – 0,40	Median
0,00 - 0,20	Insignificant

The data obtained from the questionnaires applied to the teachers helped to specify the training needs of the target users. In this sense, specific training/improvement actions were developed for each target group.

WP.4: STUDENT-RELATED STRATEGIES

WP.4 addressed the student-related strategy. It was focused on providing more attractive teaching and learning environments that would allow us to redesign education and create new and interesting teaching opportunities. WP.4 was also related to encouraging adolescents to enter basic education in Exact Sciences, Engineering, Computing, and Information and Communication Technologies careers.

Instruments used in WP4

In WP.4, validation and data collection were supported by the application and tabulation of three questionnaires, applied to students from participating schools. The first questionnaire, available online, aimed to identify the student profile and registration data that were available in VLE. For elementary school, a physical format questionnaire called "Technological Profile & Remote Laboratory" was applied and comprised of 13 items (6 related to the students' technological profile and 7 about the use of remote laboratories in class). For high school, a questionnaire was applied online, with 12 items focused on the students' profile. The second questionnaire, with 23 multiple choice items (see Appendix C), available online, sought to evaluate the satisfaction regarding the use of remote laboratories in the lesson plans by the students, through factors such as usability, learning perception, satisfaction, and usefulness. For purposes of analysis we conceptually define the subscales as follows:

- Usability: basically, related to the functionality and availability of remote laboratories;
- Learning Perception: about students' perception regarding the improvement of learning from the use of the remote laboratory in the didactic activity;
- Satisfaction: related to the educational resources added to the learning process;
- Utility: associated with motivation and satisfaction for learning. Besides the interest in repeating the experience.

This questionnaire was structured based on the questionnaires developed and used by Professor Euan David Lindsay (Lindsay, 2005), as well as the study by Lopez, Carpeno, and Arriaga (2014). The 23 items were divided into four subscales: Usability (5 items), Learning Perception (6 items), Satisfaction (6 items) and Utility (6 items), which seek to understand the degree of agreement of the students regarding the technology used. To calculate the satisfaction scores, a 5-point Likert scale was used, consisting of several elements in the form of statements, on which their degree of satisfaction should be expressed.

WP.5: Dissemination and Exploitation of Results

Dissemination and exploitation of results were related to WP.5. The success of a project is directly related to an appropriate outreach strategy. WP.5 objectives included providing information and a communication plan to increase the visibility of the project and its objectives. The works and research results were made available to the public through national publications (books, book chapters, journal articles, master's dissertations, doctoral theses, etc.), presentations at national events (Symposiums, Workshop, Congresses), or international events promoted in the area of research. The events are intended to disseminate, explore, and communicate project results. In this sense, oral presentation sessions and banners are promoted, where teachers have the opportunity to make public their work. They also provide the opportunity for teachers to contact speakers and seek to involve them in other initiatives of the same theme.

Results and Discussion

Although the InTecEdu Program began its activities in 2008, for this publication data were collected for the years 2016 to 2019. In the period analyzed, 27 Basic Education schools in the states participated in the InTecEdu Program: Santa Catarina (24), Rio Grande do Sul (2) and Minas Gerais (1). The following are some data from participating schools. The participating schools consisted of 22 urban, 4 rural and 1 indigenous rural.

Results Related to Teachers

The objectives of work package three are related to the qualification of teachers to integrate technology into their lesson plans, as well as the availability of these plans in their classes. After completing the program visits and presentation to interested schools, the teachers who participated in the program were identified. Immediately, the 120-hour course entitled "Integration of Digital Technologies in Basic Education Disciplines" began, offered as an extension course at UFSC. In this course, the teachers needed to complete at least 75% of online activities and make digital content available at VLE in at least one course that teaches. In the period 2016-2018, 398 (45.02%) out of a total of 884 teachers in partner schools participated in the course.

Linked to the course were applied questionnaires that constituted an initial diagnosis with the participating teachers. This diagnosis sought the perception of teachers about their knowledge: technological, pedagogical and, and how they perceived the integration of technology in their classrooms. The idea was to know the degree of ICT training and their use in class by teachers. The diagnosis was based on online questionnaires, available at VLE, in the initial course environment with the teachers. One called "Teaching Profile" and another called "TPACK Questionnaire". The "Teacher Profile" (see Appendix A) questionnaire consisted of 20 questions that sought to characterize the profile of the teachers participating in the program. Next, some data from this questionnaire will be presented and discussed. The questionnaire was answered by 362 of the teachers participating in the course (90.9% of the total enrolled). 84.37% were female and 15.63% were male. Figure 6 shows the distribution of teachers by age group.

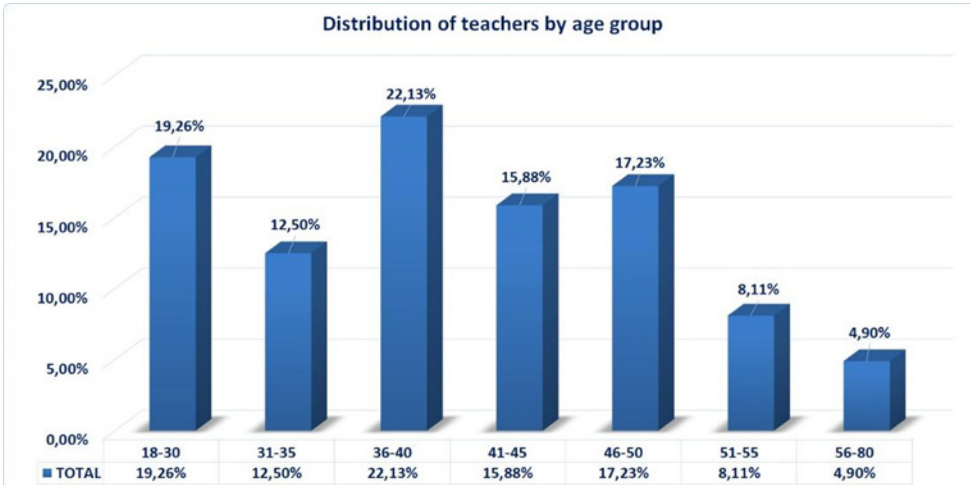

Figure 6. Distribution of teachers by age group

Associating the values by ranges we have 19.26% of teachers aged up to 30 years, 34.63% between 31 and 40 years, 33.11% from 41 to 50 years and 13.01% over 50 years.

Figure 7 shows the distribution of teachers about their experience in teaching classes in basic education. By grouping the ranges, we have 39.02% up to 10 years, 79.56% up to 20 years and 20,44% over 20 years of activity.

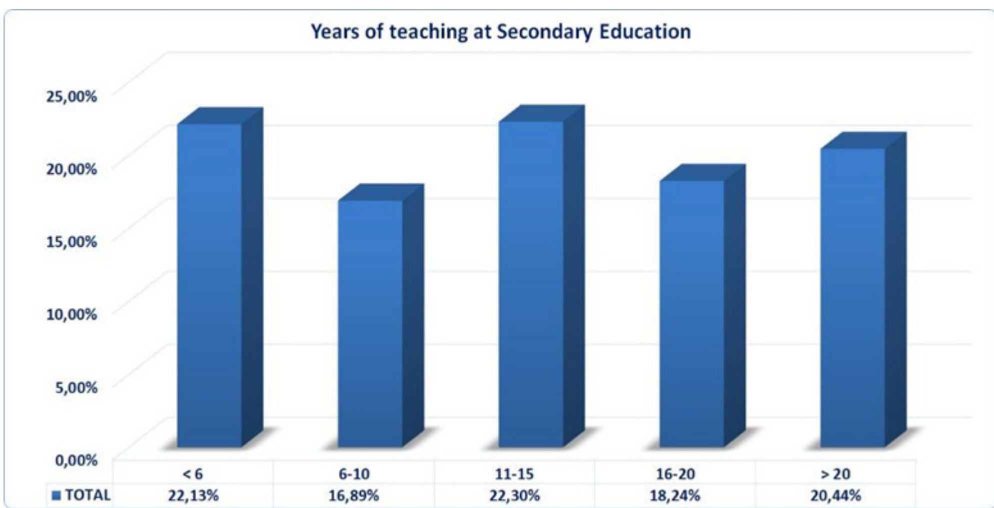

Figure 7. Years of teaching at Secondary Education

As for training, 96.33% said they had attended college (66.06% undergraduate courses, 19.27% pedagogy). Regarding postgraduate studies, 81.15% attended a specialization level, 2.08% a master's degree, and 16.77% did not attend. On the administrative dependence of the schools that worked: 63.77% declared in the state network, 32.26% municipal, and 4.30% in the federal network. No teachers from private schools were surveyed, as the focus of the program is public schools, of which 59.76% were effective / tendered and 40.24% with temporary contracts. Regarding the exercise of professional activity 64.88% report working in just one school, 60.65% in two, and 4.46% in three or more. 43 (24.71%) taught subjects in the STEM areas. Regarding the number of weekly hours dedicated to classes:

- Up to 20 hours: 9.52%
- From 21 to 39 hours: 6.80%
- 40 hours: 42.45%
- 41 hours or more: 11.22%

Regarding technology, only 1.69% said they do not have a microcomputer and 60.28% have a laptop. About how they learned to use the computer 33,67 answered "alone" and 21,09% took a specific course. Regarding the following statements:

- "Students in this school know more about computer and the Internet than the teacher", 92.59% of the teachers indicated "totally agree" (27.95%) and "partially agree" (64.65%);
- "I believe more in traditional teaching methods.", 43.54% of the teachers indicated "totally agree" (0.68%) and "partially agree" (42.86%);
- "You don't know how or for what activities you can use a computer or the Internet at school.", 35.75% of the teachers marked "totally agree" (13.61%) and "partially agree" (22.21%) and 60.20% of the teachers marked "totally disagree" (37.71%) and "partly disagree" (24.49%);
- "Lack of pedagogical support for computer and Internet use.", 76.87% of the teachers indicated "I totally agree" (43.20%) and "partially agree" (33.67%);
- "Teachers do not have enough time to prepare classes with the computer and the Internet.", 70.41% of the teachers indicated "totally agree" (34.35%) and "partially agree" (36.05%).

The "TPACK Questionnaire" (see Appendix B) was answered by 361 (90.7%) of the teachers who took the training course. The data acquired in the questionnaire were grouped, taking into account the four defined subscales and, according to the Likert Scale, the scores were aligned for each one. To obtain the reliability of the instrument, Cronbach's alpha coefficient was used. Cronbach's alpha coefficient for the questionnaire applied (50 items) was 0.91. The average score on the Likert scale was 3.65, the standard deviation for the average of the items was 0.36 and the coefficient of variation was 9.88%. The mean scores on the Likert scale for the subscales analyzed were as follows:

1. Pedagogical Knowledge (PK): 3.90
2. Content Knowledge (CK): 3.88
3. Technology Knowledge (TK): 2.91
4. Pedagogical Content Knowledge (PCK): 3.59
5. Technology Content Knowledge (TCK): 2.89
6. Technological Pedagogical Knowledge (TPK): 3.56
7. Pedagogical Knowledge of Technological Content (TPACK): 3.77

If we assume that a Likert-type scale with five satisfaction levels showing mean score values greater than 3.0 may be considered concordant, while values less than 3.0 may be considered discordant, assuming that the neutral point has a value equal to 3.0. For the number of items analyzed by subscale, only TK (2.91) and TCP (2.89) can be considered discordant, with an approximation to neutral. The other subscales show agreement. Figure 8 graphically shows the values of the mean scores on the applied Likert scale for the TPACK domains and subdomains.

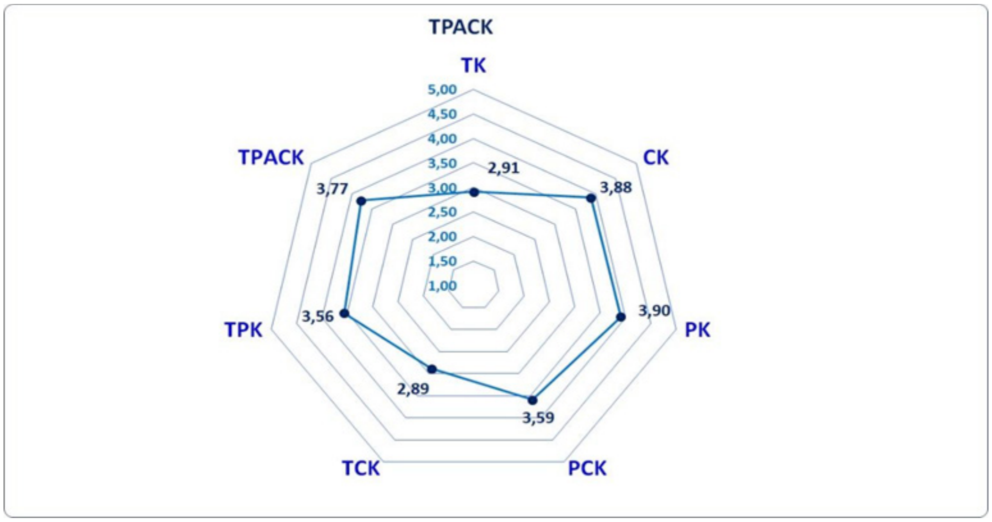

Figure 8. Average Likert Scores for TPACK Domains and Subdomains

Based on Koehler and Mishra (2008), for a better understanding of TPACK, it is necessary initially to understand the three components that compose it, Pedagogical Knowledge, content or disciplinary Knowledge, and Technological Knowledge, and later their relationships. PK is general knowledge and teaching-related skills and includes knowledge of general teaching methods. It is related to the understanding of educational theories of teaching and learning, i.e., "the knowledge that is involved in all issues related to student learning, classroom management, development and implementation of lesson plans and student assessment" (Mishra & Koehler, 2006).

The average Likert score for the nine items of the PK subscale was 3.90. Cronbach's alpha coefficient for the subscale was 0.79 (substantial), the standard deviation for the mean of the items was 0.18 and the coefficient of variation was 4.31%. In percentages, the average value for the PK was 83.10%, summing up the answers to the options "partially agree" (73.7%) and "totally agree" (9.4%).

CK is the knowledge of acts and concepts, for example, the content that must be learned in physics classes in the second year of high school. It includes knowledge of concepts used in the subject, methods, and procedures within a given field, the main facts, ideas and theories, organizational structures, evidence, evidence, established practices and approaches to the development of such a subject in a particular discipline. This corresponds to the quantity and organization that the teacher has of this knowledge, as well as the understanding of the subject to be taught (Shulman, 1986). The average Likert score for the five CK composition items was 3.88. The Cronbach's alpha coefficient for the subscale was 0.80 (substantial), the standard deviation for the mean of the items was 0.11 and the coefficient of variation was 2.93%. In percentages, the average value for CK was 81.4%, summing up the answers to the options "partially agree" (59.6%) and "totally agree" (21.9%).

The TK is the necessary knowledge to understand and use the various technologies. This knowledge is linked to the understanding of technological devices, their purpose, functionality, handling, among others. Technological knowledge is constantly changing due to the continuous advancement of technologies, and it includes the ability to learn and adapt to new technology. This technological context encompasses ICT, general-purpose software, the Internet, and related technologies such as educational software, simulations, modeling tools, remote experimentation, and more. (Koehler & Mishra, 2008). The average Likert scale score for the seven TK composition items was 2.91. Cronbach's alpha coefficient for the subscale was 0.76 (substantial), the standard deviation for the mean of the items was 0.47, and the coefficient of variation was 16.16%. In percentages, the average value for TK was 37.6%, summing up the answers to the options "partially agree" (33.9%) and "totally agree" (3.6%).

The TPACK model proposes the interaction between the three types of knowledge mentioned and that make up its core and which are the constitutive elements of current learning environments. To pursue this interaction, the TPACK model needs to go beyond an isolated view of the three types of knowledge that it encompasses. Emphasizing the connections and complex relationships between three dimensions of knowledge (its constituent elements) the model defines three new types of knowledge, namely, Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK) and Technological Pedagogical Knowledge. (TPK).

The PCK considers Pedagogy (P) and Content (C) together to provide Pedagogical Content, that is, the ability to teach a particular curriculum content. According to Shulman (1986), the PCK represents the knowledge of pedagogy that applies to the instruction of content of a specific science. For Koehler and Mishra (2008) the idea of pedagogical knowledge of content applies to the teaching of specific content. The PCK includes knowing how content elements can be organized for teaching improvement. It is focused on the representation and formulation of concepts, pedagogical techniques, knowledge of making it difficult or easy to learn certain concepts, knowledge of students' alternative conceptions and theories. The average Likert scale score for the seven PCK composition items was 3.45. The Cronbach's alpha coefficient for the subscale was 0.69 (substantial), the standard deviation for the mean of the items was 0.48 and the coefficient of variation was 13.98%. In percentages, the average value for the PCK was 62.0%, summing up the answers to the options "partially agree" (57.6%) and "totally agree" (4.4%).

Technological Content Knowledge (TCK) is the mutual relationship between content (C) and technology (T) being built from the integration of Technological Knowledge (TK) and Content Knowledge (CK), that is, knowing how to select technological resources best suited to communicate a particular curriculum content. This type of knowledge is useful for describing a teacher's knowledge and how a subject's teaching content can be transformed through the application of technology. A good example of this is computational simulations of physical phenomena that seek to illustrate the contents to which they relate. The average Likert scale score for the six TCK composition items was 2.79. Cronbach's alpha coefficient for the subscale was 0.86 (almost perfect), the standard deviation for the average of the items was 0.35 and the coefficient of variation was 12.56%. In percentages, the average value for TCK was 36.0%, summing up the answers for the options "partially agree" (24.7%) and "totally agree" (3.3%).

Technological Pedagogical Knowledge (TPK) refers to the general understanding of the application of technology in education without reference to specific content, that is, knowing how to use these resources in the teaching and learning process. TPK includes knowledge of how technology can support specific pedagogical strategies and/or classroom goals. A good example is the use of educational forums and social networking sites, which were not initially created for this purpose. The average Likert scale score for the eight TPK items was 3.56. The Cronbach's alpha coefficient for the subscale was 0.74 (substantial), the standard deviation for the mean of the items was 0.27 and the coefficient of variation was 7.39%. In percentages, the average value for the TPK was 79.8%, summing up the answers to the options "partially agree" (76.2%) and "totally agree" (3.6%).

Finally, if we consider together the three new types created (PCK, TCK, and TPK) we will have Pedagogical Technological Content Knowledge (TPACK). Koehler and Mishra (2008) argue that the true integration of technology requires understanding and negotiating the relationships between these three components of knowledge. Good teaching is not simply about adding technology to teaching and mastering existing content, but introducing technology can make new representations of concepts possible (Koehler & Mishra, 2008; Schmidt, Baran, Thompson, Mishra, Koehler, & Shin, 2009; Schmidt, Sahin, Thompson, & Seymour, 2008). The average score on the Likert scale for the seven items that make up the TPACK was 3.77. The Cronbach's alpha coefficient for the subscale was 0.73 (substantial), the standard deviation for the mean of the items was 0.28 and the coefficient of variation was 7.65%. In percentages, the average value for TPACK was 78.7%, summing up the answers to the options "partially agree" (63.5%) and "totally agree" (6.6%).

Among the 398 teachers who completed the course, 70 (17.84%) continued to use the resources in their classes. They produced and made available didactic content, produced by them, in the VLE Program InTecEdu, for 230 classes with the attendance of 6,766 students. Regarding the integration of technology in the STEM areas, 32 teachers, 67.44% of the identified teachers working in the area, provided their didactic contents: content that served 3,514 students from 118 classes from 12 schools. These had, among other resources, access to Virtual and Remote Laboratories, in lesson plans in the subjects of Science (Elementary School) and Physics and Biology (High School). To support practical activities in the STEM areas, 20 remote laboratories, with 26 instances, were made available for use in practical activities in disciplines [http://relle.ufsc.br/labs]. The integration of technology in the lesson plans also occurred through the availability of content in VLE and tablets in the classroom, where 3,252 students were served (1,898 elementary school - early years; 1,266 elementary school - final years, and 88 school years - medium).

RESULTS RELATED TO STUDENTS

A total of 6,766 students were enrolled in the InTecEdu Program VLE. This number reached 63.47% of the total enrolled students (10,659), in elementary and high school, in the participating schools. The distribution of classes and students was 131 (56.22%) and 3,804 (56.85%) for elementary education (PE), which represented 52.69% of the total enrolled at this level in schools. In high school (MS) participated 99 classes (43.78%) and 2,962 students (43.02%), which represented 86.12% of the total enrolled at this level in schools.

Regarding the integration of technology in the lesson plans, for analysis purposes, the classes were divided into two groups. In one group, technology integration included the availability of content in VLE and the use of remote laboratories. In the second group, integration was considered based on the availability of content in VLE and the use of tablets in schools. In both modalities, online activities were contemplated to be performed outside the school environment, preferably using mobile devices. For the first group, the use of VLE and integration of remote laboratories in lesson plans were accounted for 12 schools, 118 classes (22: PE; 96: MS) and 3,514 students (640: PE; 2,874: MS). The subjects attended were Physics, Chemistry, Biology, and English Language (High School) and Science (Elementary School). In the second group, where there was the integration of technology in the lesson plans, from the availability of VLE and tablets to access the content, 12 schools were attended, with 112 classes (109: PE; 3: MS) and 3,252 students (3,164: PE; 88: MS). The most attended subjects were Mathematics, Biology, Physics (High School), Mathematics, Science, Art, and Religious Education (Elementary School)

Validation and data collection were supported by the application and tabulation of three questionnaires, applied to students from participating schools. The first questionnaire aimed to identify the student profile and registration data that were available in the program VLE. For elementary school, a physical format questionnaire called "Technological Profile & Remote Laboratory" was applied and comprised of 13 items (6 related to the students' technological profile and 7 about the use of remote laboratories in class). For high school, a questionnaire was applied online, with 12 items focused on the students' profile.

Regarding elementary school, the questionnaires were applied to classes of Elementary School II (6th to 9th grade), in three schools, in the municipalities of Araranguá and Balneário Arroio do Silva, in Santa Catarina/Brazil. The questionnaires were answered by 243 students (31.88% of those who participated in the actions).

Following are the statements and answers related to the six items about the technological profile:

1. How long have you been using the computer? 31.71% less than one year, 29.27% of students use 1-3 years, 14.63% more than five years;
2. Who taught you the most about using computers and the Internet? 53.66% learned to use computers with family members, followed by 21.95% of students who said they had learned

on their own. Another 4.88% said they had learned how to use the computer with friends, 12.20% at school, 2.44% at internet cafes and 4.88% said they learned otherwise.
3. Where do you have the most access to a computer? 58.54% have more access to computers at home, 24.39% at school, 2.44% answered that they have access at Lan House (Lan House or "Web House" is a business establishment where, like a cybercafe, users can pay to use a computer with access to the Internet and a local network.), 14.63% answered elsewhere;
4. How long do you use the Internet per day? 42.11% from 1 to 3h; 18.42% <1; 4.47% from 3 to 5 and 13.16%> from 5 and 11.84% does not use;
5. Who taught you the most about using the internet? Family (47.37%); Alone (34.21%);
6. The preferred device for internet access? Computer (18.42%); Mobile (60.53%) and does not use 6.58%.

The following items are a selection of answers to questions related to student perception and satisfaction regarding the use of remote labs in class:

1. "Do you enjoy when you have the opportunity to use computers at school?" 60% of students answered "Totally Agree" and 24% marked "Partially Agree";
2. "Do you enjoy using remote labs in class?" On average 86.05% of the students answered "Totally Agree" and 13.95% marked "Partially Agree";
3. "Do you think you learned easier from the remote lab?" 90.70% of the students stated that they "learned more easily (69.77%: Totally Agree and 20.93: Partially Agree);
4. "Do you think it was easy to use the remote lab?": 91%, adding those who agree, 29%, and those who fully agree, 62%, believe it is easy to access the remote experiment. Another 7% responded neutrally and only 2% said they did not agree.
5. "Would you like to use other remote labs?" 64.65% of students said they fully agreed to want to use other remote experiments, while 21.21% said they agreed.
6. Do you prefer the traditional class without the use of remote labs? 30.94% of the students answered completely disagree and 25.95% partially disagree;

The high school student profile identification questionnaire was structured in 12 items, applied online in the VLE subject environment and was answered by 546 high school students from six schools in the municipalities of Araranguá, Balneário Arroio do Silva, in Santa Catarina, and Uberlândia/MG. Following are the data for some items:

- Age range: 72.90% from 15 to 17 years old; 23.36% from 18 to 20. High school should include students from 15 to 17 years, so a significant percentage is above the ideal maximum age for this phase.
- 73.58% said they had a personal computer;
- 84.91% said they had internet access;
- Among respondents 67.92% stated that they prefer to access via mobile devices;
- 87.74% stated that their preferred location for internet access is their residence;
- Among respondents 69.8% stated that parents have income up to 2 minimum wages;
- When asked if they would perform paid activities, 44.34% said yes;
- Regarding the daily workday, 42.86% of the students declared that they work up to 8h per day, that is, 40h weekly workday;
- Referring to the intention of students to attend an undergraduate course, 90.57% stated that they intend to attend.

The second questionnaire was applied to high school students and aimed to evaluate the satisfaction regarding the use of remote laboratories in the lesson plans by the students through factors such as usability, learning perception, satisfaction, and usefulness. 541 high school students from four public elementary schools in the municipalities of Araranguá/SC (262), Balneário Arroio do Silva/SC (78) and Uberlândia/MG (201) answered the questionnaire. Cronbach's alpha calculated for the applied questionnaire, in its total (23 items), was 0.87 (almost perfect). The average score on the Likert scale was 4.06, the Standard Deviation for the item average was 0.31 and Coefficient of Variation 7.74%.

Figure 9 graphically presents the values of the mean scores for the four scales evaluated. From the Likert scale used, with five levels of satisfaction, it is observed that two values (utility and learning perception) reached rates higher than 4 and two (usability and satisfaction) had values close to 4. It is possible to state that the results obtained for the four subscales are consistent with the statements in Appendix C.

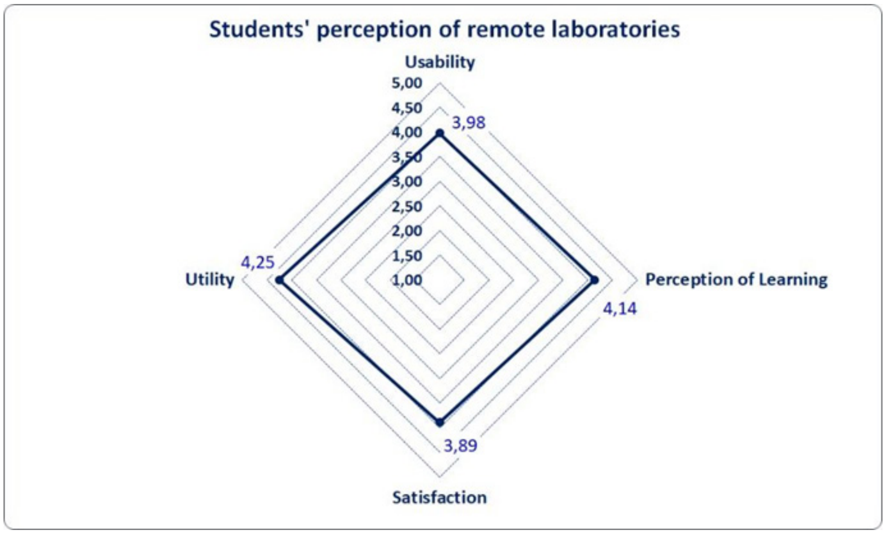

Figure 9. Use of remote experimentation. Scores for the questionnaire subscales

Figure 10 presents the percentages for the subscales of the questionnaire. Grouping the answers obtained for Totally Agree + Partially Agree and Totally Disagree + Partially Disagree, excluding the values attributed to "no opinion". We have: Totally Agree + Partially Agree = 72.2% for satisfaction; 80.7% for learning perception; 84.2% for utility and 78.8% for usability.

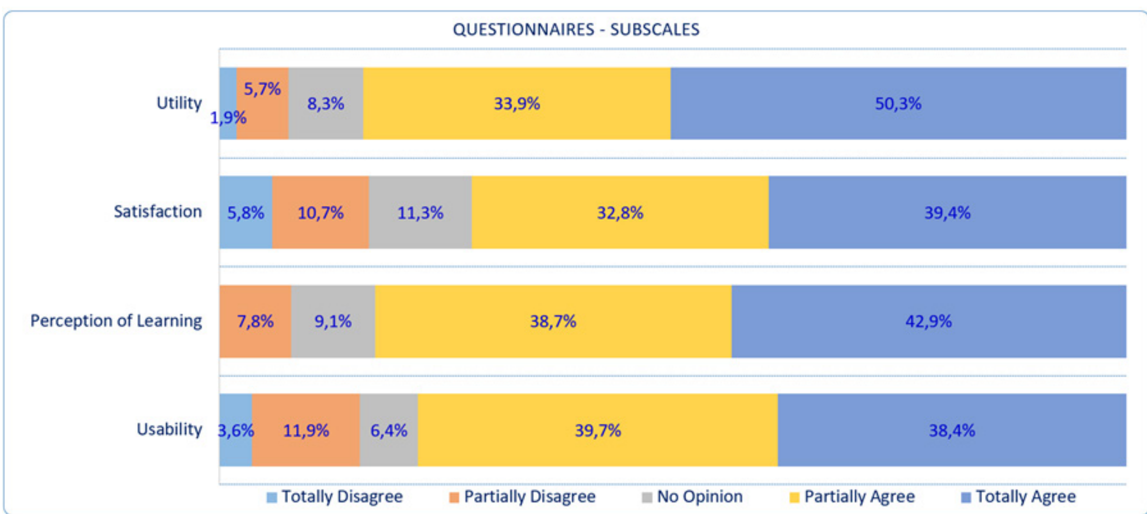

Figure 10. Percentages for the questionnaire subscales

The average scores on the Likert scale for the subscales analyzed in the four schools can be seen in Table 3. School E1 is public and federal, schools E2, E3, and E4 are schools of state administrative dependence.

Table 3. Scores for the subscales by school

Subscale	Total	E1	E2	E3	E4
Usability	3,98	4,15	3,82	3,77	3,99
Learning Perception	4,14	4,41	3,94	3,85	4,13
Satisfaction	3,89	3,88	3,74	3,79	3,99
Utility	4,25	4,12	4,20	4,37	4,31
Total	4,07	4,14	3,93	3,95	4,11

According to the 2018 School Census (INEP, 2019b), about federal schools, 97% had a computer lab, 95% had a broadband internet connection, and 75% had a science lab, and these have an average of 107.20 computers per school for student use. Having technical resources for informatics and laboratory activities, the federal school (E1) presented the best indicators. If we take into account that the census showed 701 schools in this category, with 252,431 students enrolled at the various levels available, we get an average number of 360.12 students per school and, therefore, an average value of 0.30 computers per school for student use.

The schools E2, E3, and E4, are schools of state administrative dependence. According to the 2018 School Census, about state-administered schools, 74% had a computer lab, 77% had a broadband internet connection, and 27% had a science lab. These schools average 14.25 computers per school for student use. If we take into account that the census showed 30,377 schools in this category, with 15,958,395 students enrolled at the various levels available, we get an average number of 525.35 students per school and consequently an average value of 0.027 computers per school for student use. Table 4 presents infrastructure and technology data from the program's partner schools.

Table 4. Availability of technological resources in the schools surveyed. Based on Censo Escolar/INEP 2018 (INEP, 2019b)

Item	E1	E2	E3	E4
Computer lab	YES	YES	YES	YES
Broadband Internet	YES	YES	NO	YES
Computers for student use	150	5	6	20
Science lab	YES	NO	NO	NO
Enrollment	310	937	1.439	1.868

RESULTS RELATED TO RESULTS SHARING

During the period 2016-2019, the InTecEdu program team organized and held three international events (I, II and III Ibero-American Symposium on Educational Technologies) with 2,059 participants, 663 articles submitted, and 200 (30.16%) presented in oral sessions. There were also 4 sessions of WIER (Educational Technologies Integrator Workshop), an exclusive event for teachers from participating in InTecEdu schools. In total, 515 teachers participated in WIER.

In addition to the proceedings of the event, three books were published in electronic format, which contains experiences reports of some teachers, participants of the InTecEdu Program. The books published were entitled "Integration of Technologies in Education: Innovative Practices in Basic Education". Information about the 3 volumes is given below:

- Volume 1: Available for download at https://rexlab.ufsc.br/wp-content/uploads/2019/10/Integra%c3%a7%c3%a3o-de-Tecnologias-na-Educa%c3%a7%c3%a3o-Vol-1.pdf and registered under ISBN 9788558810029;
- Volume 2: Available for download at https://rexlab.ufsc.br/wp-content/uploads/2018/04/relatos_volume_2.pdf and registered under ISBN 9788558810036;
- Volume 3: Available for download at https://rexlab.ufsc.br/wp-content/uploads/2019/08/ebook_vol_3_final_.pdf and registered under ISBN 978-85-5881-008-1.

The scientific production in period 2016-2019 included 31 Articles in Periodicals, 32 book chapters, 7 organized and published books, 70 full papers published in event annals, 2 software records obtained and 15 master guidelines.

CONCLUSION

In this document, we present the structure developed and implemented in the InTecEdu program, for the integration of digital technologies in basic education, developed by the Remote Experimentation Laboratory (RExLab) of the Federal University of Santa Catarina (UFSC), SC / Brazil. The implemented model, inspired by the "Maker Culture," has the main objective of promoting vocations, encouraging entrepreneurship, and increasing the attractiveness of STEM careers for students. We understand, in the InTecEdu Program, that to achieve this objective, it is mandatory to provide more attractive environments for teaching and learning in basic education. Environments that consider the ecology of learning, that is, that are mainly compatible with, not antagonistic to, the way children, adolescents, and young people learn.

However, unquestionably the integration of ICT in the classroom involves specific skills of teachers concerning the pedagogical use of these technologies. The Brazilian Internet Steering Committee (2019) pointed out that 55% did not take, in undergraduate courses, any discipline on the use of computers and the Internet in teaching activities. When asked about how they learned to use their computer, 90% answered "alone," and 84% stated that the absence of a specific course for the use of the computer and the Internet in classes made it difficult to use technology in their classes.

From this scenario, the InTecEdu framework was proposed, applied, and validated for the integration of technology in education, assuming that to fulfill the main objective it would be essential to develop strategies related to students and teachers. The strategies related to teachers aimed to train them to integrate technology into their lesson plans. Seeking inspiration in the Maker Culture, we sought to provide a space for the production of content and digital manufacturing in which teachers, supported by the project's execution team and graduate students, developed, modeled, and built artifacts and built digital content for integration into their lesson plans. By training teachers, it was intended to prepare them for in-class application of different methods and tools that could provide the introduction of scientific culture in the classroom, and thus arouse curiosity about science among students. About students, we sought to create new teaching and learning opportunities, in addition to extending the classroom and also the school, through remote laboratories, to support practical and VLE activities. Workshops were also held, inspired by practices of the Maker Culture to provide them with real-world skills, which can motivate them to complete their school career, encourage them through the STEM areas, and also favor their employability. To this end, extension actions were carried out that sought to articulate the resources (human and material) available in the InTecEdu Program and thus promote recreational-experimental activities, such as a science club, online courses, and workshops).

Although the InTecEdu Program started its activities in 2008, for this publication, data for the year 2016 to 2019 were collected, in which 27 Basic Education schools participated, in three states (SC, RS, and MG) in Brazil. In these 398 teachers completed participation in the training activities and 70 (17.84%) continued to use the resources in their classes. They produced and made available didactic content, produced by them, in the VLE of the InTecEdu Program, for 230 classes with the assistance of 6,766 students.

FUTURE WORK

The model developed is based on open-source resources, both in software and hardware and on open educational resources. We understand that these characteristics contribute to the continuity and sustainability of the program, as they are directly related to its scalability. Here is an observation. RExLab was created in 1997 and brings its "mission" and "vision" to contribute to the development of public education and to contribute to the strengthening of the links between technology and the social aspect. In this sense, it prioritizes open-source resources (software, hardware, and OER). These characteristics favor the dissemination of the program, as well as the sharing and socialization of the research, potentializing thus its possible reapplication, which is the objective for the continuity of the program. To support this objective, efforts are being made to disseminate the methodology implemented and the results obtained among other dissemination activities (publication of articles, presentation of works at events, workshops and seminars, etc.). Also available is a repository containing the lesson plans prepared by the teachers for integrating technology into their classes.

REFERENCES

Abdullah, M., Hussin, Z. A. & Zakaria, A. R. (2013). mLearning scaffolding model for under-graduate English language learning: Bridging formal and informal learning. *Turkish Online Journal of Educational Technology - TOJET*, *12*(2), 217-233.

Agência Nacional de Telecomunicações. (2019). *Acessos de telefonia móvel no Brasil*. https://www.anatel.gov.br/institucional/noticias-destaque/2310-brasil-registra-228-64-milhoes-de-linhas-moveis-ativas-em-maio-de-2019

Anderson, C. (2013, May 2). 20 years of Wired: Maker movement. *Wired magazine*. https://www.wired.co.uk/article/maker-movement

Apple Inc. (2008). *Apple classrooms of tomorrow: Learning in the 21st century*. https://www.apple.com/ca/education/docs/Apple-ACOT2Whitepaper.pdf

Beatty, B. J. (2006, October). Designing the HyFlex world--hybrid, flexible classes for all students [Paper presentation]. Association for Educational Communications and Technology 2006 Annual International Convention, Dallas, TX, USA.

Benbunan-Fich, R., Hiltz, S. R., & Harasim, L. M. (2005). The online interaction learning model: An integrated theoretical framework for learning networks. In S. R. Hiltz & R. G. Goldman (Eds.), *Learning together online, Research on Asynchronous Learning Networks* (pp. 18-36). Lawrence Erlbaum Associates.

Branch, R. (2009). *Instructional design: The ADDIE approach*. Springer. https://doi.org/10.1007/978-0-387-09506-6

Brazilian Internet Steering Committee. (2019). *Research about the use of information and communication technologies in Brazil – TIC Educação 2018*. São Paulo: CGI.Br. Retrieved from http://data.cetic.br/cetic/explore?idPesquisa=TIC_EDU

Consortium for School Networking. (2019). *Driving K–12 Innovation / 2019 Tech Enablers*. Retrieved from https://cosn.org/sites/default/files/2019-CoSN-Driving-K12-Innovation-Tech%20Enablers.pdf

Cope, W., & Kalantzis, M. (2009). Multiliteracies: New literacies, new learning. *Pedagogies: An International Journal*, *4*(3), 164-195. https://doi.org/10.1080/15544800903076044

Declaration on science and the use of scientific knowledge. (1999). Adopted at the *World Conference on Science for the Twenty-first Century,* Budapest, Hungary, June 26-July 1, 1999. http://www.unesco.org/science/wcs/eng/declaration_e.htm

Dick, W., Carey, L., & Carey, J. (2001). *The systematic design of instruction* (5th ed.). Addison-Wesley Educational Publishers.

Gámez, I. E. (2015). *Los Modelos Tecno-Educativos, revolucionando el aprendizaje del siglo XXI.* México. Primeira edição. Retrieved from http://www.eduteka.org/articulos/modelos-tecno-educativos

Garrison, R., Anderson, T., & Archer, W. (2000). Critical inquiry in a text-based environment: Computer conferencing in higher education. *The Internet and Higher Education, 2*(2-3), 87–105. https://doi.org/10.1016/s1096-7516(00)00016-6

Harris, J., Mishra, P., & Koehler, M. (2009). Teachers' technological pedagogical content knowledge and learning activity types: Curriculum-based technology integration reframed. *Journal of Research on Technology in Education*, *41*(4), 393-416. Retrieved from https://doi.org/10.1080/15391523.2009.10782536

Heinich, R., Molenda, M., Russell, J. D., & Smaldino, S. E. (1999). *Instructional media and technologies for learning* (6th ed.). Merrill/Prentice-Hall.

Hodson, D. & Reid, D. J. (1998). Science for all: motives, meaning and implications. *School Science Review*, *69*(249), 653-661. Retrieved from https://eric.ed.gov/?id=EJ379191

Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira. (2018). *Brazilian School Census 2017*. Retrieved from http://portal.inep.gov.br/informacao-da-publicacao/-/asset_publisher/6JYIsGMAMkW1/document/id/6730173

Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira. (2019a). *Sinopse Estatística da Educação Superior 2018*. Retrieved from http://inep.gov.br/sinopses-estatisticas-da-educacao-superior

Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira. (2019b). *Censo escolar brasileiro 2018*. Retrieved from http://download.inep.gov.br/educacao_basica/censo_escolar/notas_estatisticas/2018/notas_estatisticas_censo_escolar_2018.pdf

Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira. (2019c) *Dados sobre fluxo escolar na educação básica*. Retrieved from http://portal.inep.gov.br/artigo/-/asset_publisher/B4AQV9zFY7Bv/content/inep-divulga-dados-ineditos-sobre-fluxo-escolar-na-educacao-basica/21206

Jonassen, D.H. (1999). Designing constructivist learning environments. In C.M. Reigeluth (Ed.), *Instructional-design theories and models* (2nd ed.). Lawrence Erlbaum Associates.

Jonassen, D., Howland J., Moore, J., & Marra, R. (2003). *Learning to solve problems with technology: A constructivist perspective* (2nd ed.). Merrill Prentice Hall.

Keller, J. (1987). Development and use of the ARCS model of motivational design. *Journal of Instructional Development*, *10*(3), 2-10.

Koehler, M, & Mishra, P. (2008). Introducing technological pedagogical content knowledge. In AACTE Committee on Innovation and Technology (Ed.), *Handbook of technological pedagogical content knowledge (TPCK) for educators* (pp. 3-29). Routledge.

Koehler, M. & Mishra, P. (2009). What is technological pedagogical content knowledge? *Contemporary Issues in Technology and Teacher Education, 9*(1). Retrieved from http://www.citejournal.org/vol9/iss1/general/article1.cfm

Koh, J. H. L. (2019). TPACK design scaffolds for supporting teacher pedagogical change. *Educational Technology Research and Development*, *67*(3), 577–595. Retrieved from https://doi.org/10.1007/s11423-018-9627-5

Lage, M., Platt, G., & Treglia, M. (2000). Inverting the classroom: A gateway to creating an inclusive learning environment. *The Journal of Economic Education*, *31*(1), 30-43. Retrieved from https://doi.org/10.2307/1183338

Landis, J. R., & Koch, G.G. (1977). The measurement of observer agreement for categorical data. *Biometrics, 33*, 159. Retrieved from https://www.dentalage.co.uk/wp-content/uploads/2014/09/landis_jr__koch_gg_1977_kappa_and_observer_agreement.pdf

Lindsay, E. D. (2005). *The impact of remote and virtual access to hardware upon the learning outcomes of undergraduate engineering laboratory classes*. Department of Mechanical & Manufacturing Engineering. The University of Melbourne.

Lopez, S., Carpeno, A., & Arriaga, J. (2014). Laboratorio remoto eLab3D: Un mundo virtual inmersivo para el aprendizaje de la electrónica. *Proceedings of the 11th International Conference on Remote Engineering and Virtual Instrumentation (REV 2014)*, New Jersey: IEEE. p. 100-105. Retrieved from https://doi.org/10.1109/REV.2014.6784233

Matthiensen, A. (2011). *Uso do Coeficiente Alfa de Cronbach em Avaliações por Questionários*. Boa Vista, RR: Embrapa Roraima, Document 48. Retrieved from https://www.infoteca.cnptia.embrapa.br/bitstream/doc/936813/1/DOC482011ID112.pdf

Mishra, P. & Koehker, M. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017-1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x

Organisation for Economic Co-operation and Development. (2019). *PISA 2018 Assessment and Analytical Framework*. OECD Publishing, Paris. https://doi.org/10.1787/19963777

Puentedura, R. (2003). A matrix model for designing and assessing network-enhanced courses. *Proceedings of the III Conferencia Anual MERLOT*, Vancouver, Canada. Retrieved from http://conference.merlot.org/2003/presentations/MIC03_Puentedura_matrix.pdf

Puentedura, R. (2012). *The SAMR model: Background and exemplars*. Retrieved from http://www.hippasus.com/rrpweblog/archives/2012/08/23/SAMR_BackgroundExemplars.pdf

Robin, B., & McNeil, S. (2012). What educators should know about teaching digital storytelling. *Digital Education Review*, *22*, 37-51. Retrieved from https://www.learntechlib.org/p/114033/

Schmidt, D., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2009), Technological pedagogical content knowledge (TPACK): The development and validation of an assessment instrument for preservice teachers. *Journal of Research on Technology in Education, 42*(2), 123-149. https://doi.org/10.1080/15391523.2009.10782544

Schmidt, D., Sahin, E. B. Thompson, A. D., & Seymour, J. (2008). Developing effective technological pedagogical and content knowledge (TPACK) in preK–6 teachers. In K. McFerrin, R. Weber, R. Carlsen, & D. A. Willis (Eds.), *Proceedings of the Society for Information Technology & Teacher Education International Conference 2008* (pp. 5313–5317). Chesapeake: AACE. 2008.

Sharples, M., McAndrew, P., Weller, M., Ferguson, R., FitzGerald, E., Hirst, T., & Gaved, M. (2014). Innovating Pedagogy 2013. *Open University Innovation Report 2*. The Open University. Retrieved from https://iet.open.ac.uk/file/innovating-pedagogy-2013.pdf

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14. https://doi.org/10.3102/0013189x015002004

Siemens, G. (2004). Connectivism: A learning theory for the digital age. *International Journal of Instructional Technology and Distance Learning, 2*(1). http://itdl.org/Journal/Jan_05/article01.htm

Sotiriou, S., Anastopoulou, S., Rosenfeld, S., Aharoni, O., Hofstein, A., Bogner, F., Sturm, H., & Hoeksema, K. (2006). Visualizing the invisible: The CONNECT approach for teaching science. In *Proceedings of the Sixth IEEE International Conference on Advanced Learning Technologies (ICALT'06)*, Kerkrade, 2006, pp. 1084-1086. https://doi.org/10.1109/ICALT.2006.1652636

Swan, N. (2014, July 6). The 'maker movement' creates D.I.Y. revolution. *Cristian Science Monitor*. Retrieved from https://www.csmonitor.com/Technology/2014/0706/The-maker-movement-creates-D.I.Y.-revolution

Talbert, R. (2012). Inverted classroom. *Colleagues, 9*(1), Article 7. Retrieved from http://scholarworks.gvsu.edu/colleagues/vol9/iss1/7

Teleco. (2019). *Estatísticas do Brasil - Geral*. Retrieved 09.07.2019 from https://www.teleco.com.br/estatis.asp

Tolu, A. T., & Evans, L. S. (2013). From distance education to communities of inquiry. In Z. Akyol & D. R. Garrison (Eds.), *Educational communities of inquiry: Theoretical framework, research and practice* (pp. 45-65). IGI Global. https://doi.org/10.4018/978-1-4666-2110-7.ch004

APPENDIX A: TEACHER PROFILE QUESTIONNAIRE

1: Gender:
- Male
- Female

2: Age range:
- 18-30 years
- 31-35 years
- 36-40 years
- 41-45 years
- 46-50 years
- 51-55 years
- 56-80 years

3: Teaching experience:
- From 6 months to 5 years
- From 6 to 10 years
- From 11 to 15 years
- From 16 to 20 years
- More than 20 years

4: Education level:
- Higher Education – Licenciatura (Courses that qualify to teach specific subjects in middle school)
- Higher Education – Pedagogy (Course that qualify to teach in elementary school)
- Higher Education – others
- High School – Magistério (High school course that qualifies to teach in kindergarten)
- Superior Magistério (High school course that qualifies to teach in elementary school)
- High School – others

5: Postgraduation modality:
- Specialization (minimum of 360 hours)
- Did not or has not completed any postgraduate course
- Master's degree
- Doctorate degree

6: Education networks in which it operates:
- State public education
- Municipal public education
- Private education
- Public federal education

7: Employment bond:
- Hired through public selective process
- Hired through contract
- Temporary contract

8: Number of schools where you operate:
- One school
- Two schools
- Three schools or more

9: Subject(s) you teach:

- Arts
- Kindergarten
- Elementary School
- Special Education
- English
- History
- Geography
- Math
- Chemistry
- Physics
- Philosophy
- Sociology
- Physical Education
- Portuguese
- Other subjects

10: If you have checked the "Other Subjects" option in the previous question. Please indicate the subjects:

11: Weekly hours dedicated to classes:

- 20 hours or less
- From 21 to 39 hours
- 40 hours
- 41 hours or more
- I don't want to answer

12: Type of computer you have at home:

- Portable computer
- Desktop
- Tablet
- I don't have a computer

13: How you learned to use your computer:

- Alone
- Did a specific course
- With other people (children, relative, friend, etc.)
- With another school teacher or educator
- With students/with a student
- Did not learn to use computer and / or Internet

14: Regarding the statement: "The students at this school know more about computers and the Internet than the teacher". You?

- Totally agree
- Partly agree
- Does not agree or disagree
- Partially disagree
- Strongly disagrees
- I don't know

15: Regarding the statement: "I believe more in traditional teaching methods". You?

- Totally agree
- Partly agree
- Does not agree or disagree
- Partially disagree
- Strongly disagrees
- I don't know

16: Regarding the statement: "You don't know how or for what activities you can use the computer or Internet at school". You?

- Totally agree
- Partly agree
- Does not agree or disagree
- Partially disagree
- Strongly disagrees
- I don't know

17: Regarding the statement: "Lack of pedagogical support for the use of computers and the Internet". You?

- Totally agree
- Partly agree
- Does not agree or disagree
- Partially disagree
- Strongly disagrees
- I don't know

18: Regarding the statement: "Teachers do not have enough time to prepare classes with the computer and Internet". You?

- Totally agree
- Partly agree
- Does not agree or disagree
- Partially disagree
- Strongly disagrees
- I don't know

19: Have you accessed the Internet using a cell phone (smartphone)?

- Yes
- No

20: Do you have Internet access at home?

- Yes
- No

APPENDIX B: TPACK QUESTIONNAIRE

Num.	Type	Items	TD	PD	NO	PA	TA
TK is necessary knowledge to understand and use the different technologies. This knowledge is linked to the understanding of technological devices, their purpose, functionality, handling, among others.							
1	**TK**	I know how to solve my problems related to ICT.					
2	**TK**	I assimilate technological knowledge easily.					
3	**TK**	I keep up to date with the most important new technologies.					
4	**TK**	I have been using and testing technology for a long time.					
5	**TK**	I know many different technologies.					
6	**TK**	I have the technical knowledge I need to use the technologies.					
7	**TK**	I have found enough opportunities to work with different technologies.					
CK is the knowledge of the acts, concepts and knowledge that exist in a particular domain, for example, they are the contents that must be learned in class.							
8	**CK**	I have sufficient knowledge in the development of contents of the subject(s) that I teach.					
9	**CK**	I know the theories and basic concepts of the subject(s) I teach.					
10	**CK**	I keep up to date with recent developments and applications in the area(s) of the subject(s) I minister.					
11	**CK**	I often participate in conferences, congresses and activities in my content area.					
12	**CK**	I am familiar with recent research and key trends in the subject area(s) I teach.					
PK is general knowledge and skills related to teaching and includes knowledge of general teaching methods. It is related to the understanding of educational theories of teaching and learning.							
13	**PK**	I know how to apply, in class, a way of thinking related to the subject(s) I minister. (Mathematical thinking, scientific thinking, literary thinking, historical thinking, etc.)					
14	**PK**	I have several methods and strategies to develop my knowledge about the subject(s) I minister.					
15	**PK**	I know how to guide students' discussions during group activities. Thus, minimizing individual differences.					

16	**PK**	I know how to adapt my teaching to what the students understand or do not understand in each moment.					
17	**PK**	I know how to adapt my teaching style to students with different learning styles.					
18	**PK**	I know how to use different methods and techniques for assessing student learning.					
19	**PK**	I know how to apply different theories and approaches to learning (eg, Constructivist Learning, Theory of Multiple Intelligences, Research-Based Learning, etc.)					
20	**PK**	I am aware of the students' most common difficulties and misunderstandings when it comes to understanding content.					
21	**PK**	I can motivate students' creative thinking in the classes I teach.					
PCK considers Pedagogy (P) and content (C) together to provide Pedagogical Content Knowledge, that is, the ability to teach a certain curricular content.							
22	**PCK**	In the subject(s) I teach, I know how to guide the resolution of problems related to the content presented to students, for group work.					
23	**PCK**	I know how to select effective teaching approaches to guide students' thinking and learning in the area(s) of the subject(s) I teach.					
24	**PCK**	In the subject(s) I teach, I know how to guide students to use each other's thoughts and ideas in group work.					
25	**PCK**	In the subject(s) I teach, I know how to guide and motivate students' reflective thinking.					
26	**PCK**	In the subject(s) I teach, I know how to guide and motivate students in planning their own learning.					
27	**PCK**	I can make connections between subjects related to my content area and between my content area and other disciplines.					
28	**PCK**	I can relate subjects in my content area with external activities (outside school).					
TCK is the mutual relationship between content (C) and technology (T) being built from the integration of TK and CK, that is, knowing how to select the most appropriate technological resources to communicate a given curricular content.							
29	**TCK**	I know the technologies I can use to illustrate difficult content in the subject(s) I teach					
30	**TCK**	I know sites with online materials to study the content(s) of the subjects I teach.					

31	**TCK**	I know that ICT applications are used by professionals in the subject area(s) I teach.					
32	**TCK**	I manage to develop activities and class projects involving the use of technologies.					
33	**TCK**	I can come up with a lesson plan using educational technologies.					
34	**TCK**	I know ICT resources that I can use to better understand the content of the subject(s) that I teach.					
TPK refers to the general understanding of the application of technology in education without referring to specific content, that is, knowing how to use these resources in the teaching and learning process.							
35	**TPK**	I know how to select technologies that can improve the approach to a particular lesson or lesson plan.					
36	**TPK**	I know how to select technologies that improve student learning in a lesson.					
37	**TPK**	I know how to use ICT in teaching as a tool to share ideas and think together					
38	**TPK**	I know how to use ICT in teaching as a tool for students' reflective thinking					
39	**TPK**	I know how to use ICT in teaching as a tool for students' creative thinking					
40	**TPK**	I know how to use ICT in teaching as a tool for students to plan their own learning					
41	**TPK**	I know how to use ICT in teaching as a tool for students' critical thinking					
42	**TPK**	I am able to select useful technologies to support and support my teaching career.					
Technological Pedagogical Content Knowledge or Technological, Pedagogical and Content Knowledge							
43	**TPACK**	I know how to teach classes that adequately combine content, technologies and learning methods.					
44	**TPACK**	I know how to select technologies to use in classes that improve the content I teach, the way I teach them and what students learn.					
45	**TPACK**	I know how to use strategies that combine content, technologies and teaching approaches that I learned in my teaching materials for the class.					
46	**TPACK**	I can guide and help my colleagues in the integration of content, pedagogical and technological knowledge.					
47	**TPACK**	I can select which technologies improve the content of the lessons.					

48	**TPACK**	In the subject(s) I teach, I know how to use ICT as a tool for sharing ideas and collaborative work.					
49	**TPACK**	I can successfully teach by combining content, pedagogy and technological knowledge.					
50	**TPACK**	I can teach a subject with different teaching strategies and educational technologies					

APPENDIX C: STUDENT SATISFACTION QUESTIONNAIRE

The following questionnaire consists of several elements in the form of statements, on which your degree of agreement must be expressed and decide whether you totally agree (TA) partially agree (PA), No Opinion (NO), partially disagree (PD) and totally disagree (TD).

Usability

1.	Using the remote lab(s) was simple.
2.	I found no problems to perform the actions I wanted in the lab(s).
3.	In relation to the remote experiment, the waiting time in the queue made it difficult to carry out the activities.
4.	The explanatory information on the page contributed to the handling of the remote lab(s).
5.	The execution time of the remote lab(s) was sufficient to carry out my activities.

Learning Perception

1.	The use of the remote lab(s) improved my understanding of the theoretical concepts that were addressed in practice.
2.	The use of the remote lab(s) helped to relate the concepts studied in the classroom with my daily life.
3.	The use of the remote lab(s) contributed to my learning.
4.	Remote experimentation was an effective learning experience.
5.	The acquired skills were valuable for my learning.
6.	The way in which the remote lab(s) was approached in the classroom contributes to problem solving.

Satisfaction

1.	In general, I am satisfied with the remote lab(s)
2.	Remote experimentation was relevant to my studies.
3.	The use of the remote lab(s) increased my motivation to learn more about the discipline
4.	I would advise my colleagues to use the remote lab(s).
5.	I would like to use other remote labs in class.
6.	The use of the remote lab(s) has improved communication with my colleagues.

Utility

1.	Regarding remote experimentation, I was convinced that I was carrying out a real experiment, not a remote one.
2.	I believe that it is possible to achieve learning similar to that acquired in a face-to-face laboratory.
3.	The possibility of accessing the remote lab(s) at any time of the day and from anywhere is very useful to better plan the study time.
4.	The use of the remote lab(s) enabled me to take experimental classes in the discipline.
5.	Conducting experiments in remote lab(s) can improve performance in a real lab.
6.	The remote lab(s) can provide new ways of learning.

BIOGRAPHIES

Juarez Bento Silva was born in Sombrio/SC, Brazil on August 12, 1959. He received MSc and PhD degrees in Computer Science and Knowledge Management at Federal University of Santa Catarina, Brazil in 2002 and 2007 respectively. He is an Associate Professor in the Special Interdisciplinary Coordination of Information and Communication Technologies of the Federal University of Santa Catarina Science, Technology and Health Center since 2010. He coordinates the Remote Experimentation Laboratory (RExLab). Professor Silva has published over 36 book chapters and 10 books. His major interest in research is educational technology with special attention in the use of virtual and remote laboratories in the processes of teaching and learning.

Isabela Nardi Silva received her MSc degree in Information and Communication Technologies at Federal University of Santa Catarina in 2019. She has five years of experience in educational technologies, being 2 of these years dedicated to teaching informatics, robotics and entrepreneurship. She has experience with development of virtual learning environments such as MOODLE, WIKI and EDX. Currently she is a Robotics Instructor at the Social Service of Industry School. She teaches for children of ages between ten to fifteen years old.

She is a collaborator of the Remote Experimentation Laboratory since 2015, being one of the developers of Labs4STEAM, a collaborative platform for sharing lesson plans. Her main interests include educational technology, teacher education and student empowerment.

Simone Meister Sommer Bilessimo received MSc and PhD degrees in Production Engineering at Federal University of Santa Catarina, in 1999 and 2007 respectively. She has 20 years of teaching experience (technical, higher and postgraduate).She is currently an Adjunct Professor level IV in the Special Interdisciplinary Coordination of Information and Communication Technologies of the Federal University of Santa Catarina Science, Technology and Health Center since 2012. Simone has been acting on the following subjects: entrepreneurship, Maker Culture, technology integration in education and knowledge management. She is assistant coordinator at Remote Experimentation Laboratory (RExLab).