

## **TAEP4.0: Teacher Assistance Educational Process Based in the Context of Education 4.0**

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***Abstract.** This dissertation presented an educational process to assist Basic Education teachers in preparing classes with technological resources, focusing on the skills and competencies necessary for Education 4.0 called TAEP4.0 (Teacher Assistance Educational Process). The ADDIE model was used to guide the development and evaluation of TAEP4.0 through studies. The results indicated that TAEP4.0 could increase teachers' knowledge and interaction with the characteristics of Education 4.0, such as integrating Computing and Informatics into classes and encouraging 21st-Century skills and competencies. In general, it is believed that TAEP4.0 can contribute to the advancement of Education 4.0, mainly in schools with few resource options.*

### **1. Introduction**

In Education 4.0, the learning process needs to be personalized so that students are protagonists in constructing their knowledge [Hartono et al., 2018]. Furthermore, learning is focused on innovation through individual and collective practices involving technological resources [Himmeloglu et al., 2020]. In this context, the teacher acts as a facilitator and needs to be available for complex issues [Hartono et al., 2017; Ciolacu et al., 2018; Silva et al., 2021b]. Moreover, teachers need to help students with motivation, improve skills and competencies, and provide adequate support to build new knowledge through activities [Jumari et al., 2016; Silva et al., 2021b]. Based on these characteristics, Education 4.0 can be defined as a student-centered learning paradigm that seeks to prepare them for the challenges of the 21st century, including the use of technological resources and processes and the development of skills and competencies [Himmeloglu et al., 2020; Maria et al., 2018; Mourtzis, 2018; Ciolacu et al., 2017; Puncreobutr, 2016].

Moreover, the Brazilian Computer Society (SBC) seeks to add knowledge of the area of Computing in the Basic Education curriculum through the Common National Curriculum Base (BNCC). This knowledge is organized into three axes, being Computational Thinking (ability to understand, define, model, compare, solve, automate and analyze problems (and solutions) methodically and systematically), Digital World (understand the digital world so that the student can take ownership of the processes that occur around it, both digital and real), and Digital Culture (communication and expression through the Digital World, requiring literacy in digital technologies) [SBC, 2019]. For SBC, “the teaching of Computing in all Basic Education is fundamental, as

only then will it be possible to train citizens with the knowledge and skills needed for life in the 21st-Century” [SBC, 2018], which is characteristic of Education 4.0.

One relevant aspect of this research is to allow teachers to put Education 4.0 into practice from the technological resources available at school. Also, it is possible works the three axes of Computing education proposed in the BNCC. Thus, this dissertation aimed to present an educational process to assist Basic Education teachers in elaborating classes using technological resources to encourage 21st-Century skills and competencies, called TAEP4.0 (Teacher Assistance Educational Process). The TAEP4.0 was proposed to guide the classroom dynamics, enable the construction of knowledge, and encourage 21st-Century skills and competencies in students, such as computational thinking, teamwork, critical thinking, among others [Silva, 2020]. The specific goals of this research were: (1) Build a knowledge base about educational practices that support the formation of students for the development of 21st-Century skills and competencies; (2) Organize and propose an Educational Process to teachers' support to design classes and projects to encourage 21st-Century skills and competencies; and (3) Evaluate and evolve TAEP4.0 and, through studies, present evidence on teacher support in the context of Education 4.0.

In this context, the ADDIE model was used to achieve the goals. ADDIE was chosen among the instructional design models because it is consolidated in the literature, one of the most used and investigated [Aldoobie, 2015]. ADDIE is an acronym for the stages Analyze, Design, Develop, Implement and Evaluate and was chosen for the organization of TAEP4.0, as showed in Section 3. In the Analyze stage, four preliminary studies were carried out with 202 students from different institutions and educational levels. Simultaneously, a Systematic Mapping Study (SMS) was performed through automatic and manual searches (goal 1). In the Design stage, different possibilities and characteristics were identified for working Education 4.0 in practice (goal 2). In the Develop stage, TAEP4.0's steps and activity suggestions were defined (goal 2). In the Implement stage, a study with four specialists in Informatics in Education, one High School and Technical Teacher, and one Higher Education Professor was carried out (goal 3). In the Evaluate stage, a study was carried out with four elementary and high school teachers, involving 415 students. Finally, a study was carried out with two managers of the Municipal Secretariat of Education (SEMED) of Manaus (goal 3). In this last study, the managers commented on the possibility of TAEP4.0 be indicated by SEMED for the teacher training and elaboration of school projects with technologies resources [Silva, 2020].

In Section 2, state of the art about Education 4.0 will be presented. In Section 3, the methodology used for the proposal, development, and evaluation of TAEP4.0 will be presented. Section 4 offers the latest version of TAEP4.0. In Section 5, the contributions of the dissertation will be presented; Finally, in Section 6, the final considerations will be made.

## **2. State of Art**

Education 4.0 is highlighted because the traditional teaching methods are reaching their limit regarding students' formation for the contemporary world. In this regard, an example of a traditional teaching method can be considered when the teacher seeks to pass the contents through theoretical classes or proposes repetitive activities without practical context. In the same way, the initiatives in Education 4.0 can prepare young to adapt and have a dynamic mentality, know how to solve problems creatively and

collaboratively, create innovative solutions and products, and learn how to deal with technological resources and processes. This happens because it is believed that whoever will be successful in the future will be a country with innovation, creativity, and skill in technology [Angrisani et al., 2018].

The need to disseminate Education 4.0 was realized from SMS, which indicated that formation should start from Basic Education, such as Elementary and High School [Silva et al., 2021b]. The SBC also recommends this formation in its guidelines for teaching Computing in Basic Education [SBC, 2019]. In this way, students could gain greater knowledge in technology when entering Higher Education. Also, they could improve and develop the skills and competencies relevant to the contemporary world [Silva et al., 2021b]. In this SMS few studies were found on Education 4.0 focus on teacher training to use technological resources, even though these are some of the main ones impacted by the changes that occurred in education [Silva et al., 2021b]. Thus, one of the significant challenges is investigating ways to implement Education 4.0 in practice through teacher support [Himmeltoğlu et al., 2020].

In the literature, some works were identified that address teacher support through Education 4.0 resources such as Artificial Intelligence and Gamification. Two of these works will be listed below:

1. Pedagogical Decision-Making Process (PDMP): used to help teachers and tutors (education professionals) make decisions through artificial intelligence. In this way, this process helps to detect pedagogical problems in the learning environment. It helps to define patterns and trends related to these issues. Moreover, it helps to monitor and assess whether decisions made by teachers were effective or not by comparing student performance [Paiva et al., 2016].
2. Authoring Gamified Intelligent Tutoring Systems (GITS): used to support teachers' authorship (total or partial). This tool has incorporated features that allow the reuse of previous GITS configurations. Thus, the teacher can apply a model, reuse curriculum and educational resources to reduce the effort needed to create a GITS. In addition, teachers can select game design elements and target behavior to be added to the GITS [Dermeval et al., 2018].

This section presented two works that aimed to support teachers through technological resources. In this dissertation, we present TAEP4.0, which seeks to support teachers in creating classes using the technological resources available in their schools. When looking at TAEP4.0, it is possible to notice some similarities and differences between the works presented in this section. Similar to works presented, TAEP4.0 foresees a diagnostic evaluation so that the teacher can identify the learning problem, which allows him to align his classes according to the needs of the students. In addition, TAEP4.0 foresees continuous monitoring of the teacher in projects developed in class through a formative assessment. Additionally, TAEP4.0 provides for teacher authorship through decision-making about the elements that will be part of their classes. Adjustments in the projects can be made in partnership with other teachers and/or coordination of Informatics in Education. Unlike the works presented, TAEP4.0 was organized in a simple but instructional and interactive way so that the teacher can use it even with little knowledge in the area of Informatics and Computing. Besides, TAEP4.0 has two versions: clickable PDF and website, so that teachers can use it even in schools with few financial and technological resources, such as riverside schools in Amazonian communities [Silva et al., 2020c]. TAEP4.0 suggests some tools, examples, activities

for the teacher to develop their class in the best possible way, following the characteristics of an Education 4.0. The methodology adopted for the organization and evaluation of TAEP4.0 will be presented in Section 3.

### 3. Methodology

Different ways to use ADDIE were noticed within the context of Education 4.0, such as developing a mobile application [Karim et al., 2018] and designing a Learning Management System Platform Moodle [Wijiastuti et al., 2019]. Therefore, ADDIE proved to be more recommended for the organization of TAEP4.0. Besides, the aim was to create a technological solution to support teachers, unlike other instructional design models such as Merrill's principles of instruction and Gagne's nine events of instruction that focus on developing student experiences [Bouchrika 2021]. The use of ADDIE differs from other works in this dissertation, as it was inspired by the recommendations of the framework TPACK (Technological Pedagogical and Content Knowledge) which indicates that the effective integration of technology in education should be carried out from three perspectives, such as technological knowledge, knowledge of the content, specific to the area of expertise, and pedagogical knowledge [Herring et al., 2016]. Thus, the ADDIE model allowed us to identify evidence on Education 4.0 in the literature (Analyze and Design stages) and bring professionals in Education and Computing into the development of TAEP4.0 through studies (Implement and Evaluate stages). In this dissertation, ADDIE served as a methodological process for developing TAEP4.0 [Silva et al., 2021a].

#### 3.1 Analyze Stage

In the **Analyze** stage of ADDIE, initially, four preliminary studies were carried out with 202 students from 4 educational institutions to verify the contribution of some educational technologies to the context of Education 4.0. Through preliminary studies, it was possible to observe how technologies can contribute to developing 21st-Century skills and competencies such as creativity, problem-solving, teamwork and communication. The teachers chose the technologies used, being: 1) Digital Storytelling with STEAM (creation of digital stories through interdisciplinarity) with 120 students from the 3rd-grade high school [Silva et al. 2019a]; 2) Scratch with Creative Learning Spiral (creating digital games through learning by doing) with 25 students from the 5th year of Elementary School [Silva et al. 2019b]; 3) Unplugged Computing (teaching of programming logic through mathematical challenges) with 25 students from 4th to 9th year of Elementary School [Silva et al. 2020c], and 4) Educational Robotics (projects with physical robots, simulators, and drones) with 32 students from the undergraduate Computer Science and postgraduate in Informatics [Silva et al. 2020a]. In parallel, an SMS was conducted about Education 4.0 and 21st-Century skills and competencies, where automatic searches were performed in digital libraries, such as SCOPUS, ACM, IEEEExplore, and manual searches in the SBIE and RBIE proceedings. After the complete reading of the papers, 78 publications were considered for the research [Silva et al., 2021b]. In general, the analyze stage contributed to identifying and experiencing characteristics of Education 4.0.

#### 3.2 Design Stage

In the **Design**, the findings of preliminary studies and SMS were verified. The preliminary studies contributed to experience ways of work as content personalization

and active learning through projects and allowed to gain experience to propose a process in this context. In addition, some technologies that are suggested in TAEP4.0 were tried. The SMS contributed to the definition of the research scope and allowed a direction for this master's dissertation [Silva, 2020]. Also, the SMS helped to identify different possibilities and characteristics for working with Education 4.0 in practice. These possibilities are reflected in the steps of TAEP4.0 through active methodologies (Collaborative and Project-Based Learning) and educational technologies (Robotics and Block Programming). The characteristics worked on in TAEP4.0 are: (a) student protagonism; (b) active learning; (c) practical activities; (d) development of 21st-Century skills and competencies; and (e) experience with technological resources and processes [Silva et al., 2021b]. In general, the Design stage contributed to defining the steps of TAEP4.0 in the form of a diagram.

### 3.3 Develop Stage

In the **Develop** stage, a prototype of TAEP4.0 was presented in a clickable PDF format<sup>1</sup> to allow the teacher to use and interact with the process. Each step of TAEP4.0 contains instructions and suggestions for tools that can help the teacher prepare activities based on Education 4.0. TAEP4.0 instructions must be performed following the teacher's lesson plan. TAEP4.0 can be used at any level of education; however, the priority was given to Basic Education in this research. TAEP4.0 was organized according to the BPMN (Business Process Model and Notation) model for structuring teachers' workflow, as shown in the diagram in Figure 1. TAEP4.0 is composed of thirteen steps divided into three main activities, being (a) Planning activity (activities that the teacher needs to carry out before class): Define Scope, Check Technological Resources, Prepare Diagnostic Evaluation, Set Challenges-Problems, Define Project, Prepare Support Materials, and Organize Project; (b) Execution activity (activities that the teacher performs during the class): Apply Diagnostic Evaluation, Apply Project, Learn by Doing, and Prepare Formative Evaluation; and (c) and Verification activity (activities that represent dynamism during classes through the relationship between teacher and students): Conduct Formative Evaluation, Reflect and Share. These steps reflect the features highlighted in the Design stage. However, they can be omitted or adapted by the teacher to maintain innovation, creativity, and decision-making in selecting elements to compose the lessons. These steps are detailed in Silva et al., (2020).

In TAEP4.0, some steps were taken strategically to interconnect the activities and make the flow as natural as possible for the teacher. The change from one activity to another within the process is called transition. Thus, the Preparing and Applying Diagnostic Assessment steps allow the first transition of the process (between Planning and Execution activities), where the teacher initially checks what is available to him, such as resources and materials. Then, the teacher identifies the students' needs, adjusting and finalizing their planning adequately and closer to their reality. Afterward, the teacher organizes and proposes the project to the students, which characterizes the second transition of the process (between Planning and Execution activities). In TAEP4.0, the emphasis is on the Learning by Doing step because there is active student participation. The Learning by Doing step contributes to a more significant relationship between teacher and students, causing a series of transitions between the Execution and Verification activities. This dynamism is represented through conditionals that indicate

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<sup>1</sup> <https://doi.org/10.6084/m9.figshare.14916609.v1>

that the teacher needs to monitor and provide the necessary guidance while the students are producing their projects. In general, the Develop stage contributed to creating the TAEP4.0 process in an instructional and interactive way, with targeting for materials and resources of teacher support.

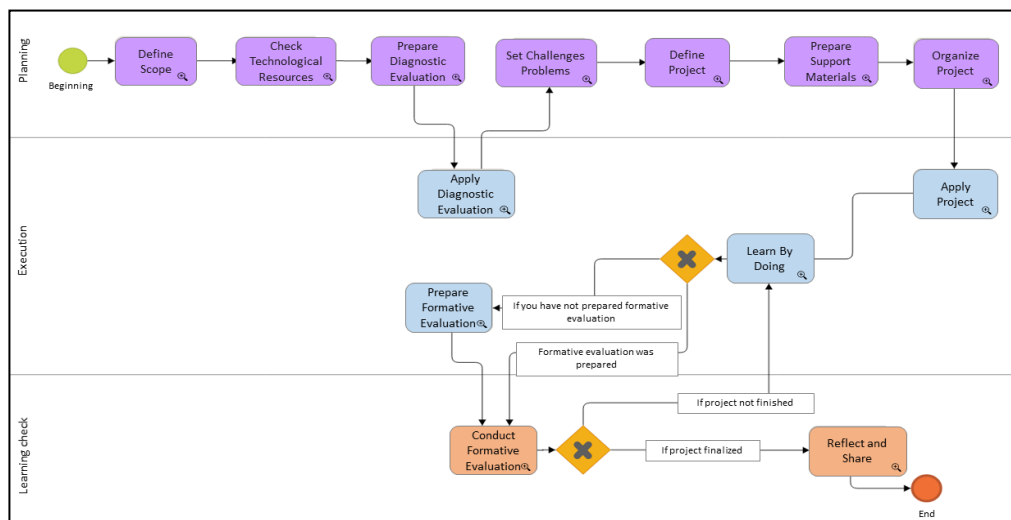


Figure 1. TAEP4.0 Diagram [Silva 2020].

### 3.4 Implement Stage

In the **Implement** stage, an exploratory study was carried out with six educators from 3 educational institutions, including specialists in Informatics in Education and teachers of Computing [Silva et al. 2020b]. As a result, educators prepared the planning of their projects using TAEP4.0 steps. In the end, educators delivered their project plan and answered their degree of acceptance about TAEP4.0 through a post-use questionnaire based on the Technology Acceptance Model (TAM3) indicators [Venkatesh and Bala, 2008], being Perceived Ease of Use, Perceived Usefulness, and Intention to Use. This exploratory study contributed to assessing the steps of TAEP4.0, making it possible to verify with the educators the excesses, inconsistencies, and ambiguities present in the process [Silva et al. 2020b]. In general, the Implement stage contributed to restructuring the TAEP4.0 diagram and adjusting the content arranged in each step, according to the feedback from the participants.

### 3.5 Evaluate Stage

In the **Evaluate** stage, TAEP4.0 was fully used by four teachers of Basic Education from the same institution for planning and executing projects, with the participation of 415 students. Therefore, training and use of TAEP4.0 were conducted for three months. This case study contributed to assessing TAEP4.0 as a whole and realizing the benefits of this process for teachers. From the data analysis, it was realized that TAEP4.0 could contribute to the teaching and learning processes. The teacher knows the difficulties and problems that each student faces in their learning process through the projects. In this way, the teacher can reorganize the project to help students with these difficulties. If the problems persist, he will be able to plan future projects [Silva, 2020]. After the case study with teachers and students of Basic Education, the TAEP4.0 was organized in web format (Figure 2). This latest version of TAEP4.0 was evaluated by two educational managers from the Municipal Secretariat of Education (SEMED) of Manaus to verify the feasibility of TAEP4.0 being used by public schools in the teacher's

training to encourage the use of technological resources. Through data analysis, it was identified that TAEP4.0 could promote 21st-Century skills and competencies through projects, work on student independence, and contribute to the insertion of computing in the curriculum, besides, to have the potential to be used by SEMED for the training of teacher in the context of Education 4.0 [Silva, 2020]. In general, the Evaluate stage contributed to verifying the stages and activities of TAEP4.0 through the use and feedback of teachers and managers. Also, the contribution of these projects to the learning of 21st-Century skills and competencies was verified.

#### 4. Educational Process TAEP4.0

TAEP4.0 is available on the web at the following link (<https://sites.google.com/view/taep/home>). In each step of TAEP4.0, there are instructions to contextualize Education 4.0 to the teacher and help him create his projects. In short, in TAEP4.0, the teacher prepares an activity based on a scope document available in TAEP4.0. In the Define Scope step, the teacher defines the context of his class, how he can work and what skills he can encourage in his students (Figure 2). Afterward, the teacher chooses the educational technology. Therefore, some suggestions for educational technologies are made available on the Check Technological Resources step screen, such as Gamification, Block Programming, Educational Robotics, Augmented Reality, and Digital Storytelling. Among the technology options, some examples of activities with recyclable materials are presented so that it is possible to disseminate the characteristics of an Education 4.0 even with few financial resources.

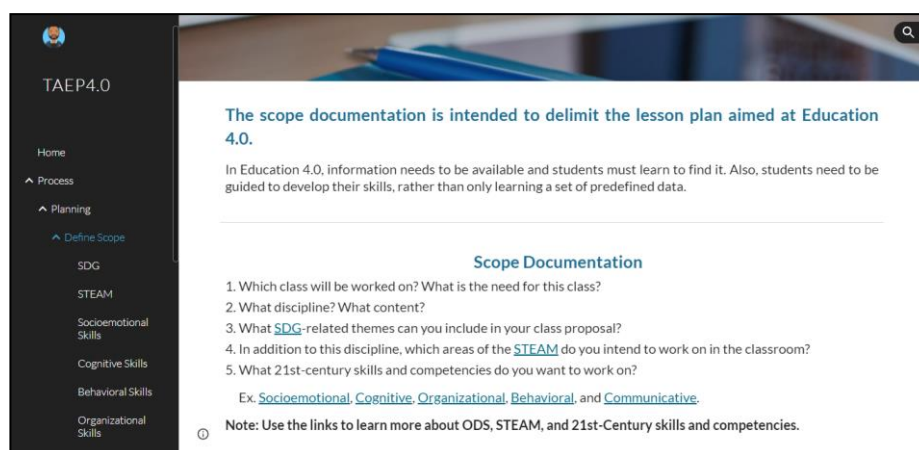


Figure 2. Define Scope Screen [Silva, 2020].

#### 5. Contributions of the Dissertation

The main contributions of this master's dissertation are presented below:

- a) Organization and evaluation of an educational process that allows the preparation of classes and educational projects in the context of Education 4.0 (Design, Development, Implement, Evaluate stages of ADDIE).
  - TAEP4.0 as a support resource for the insertion of Computing and Informatics in Basic Education schools.
  - TAEP4.0 as a resource to support the teacher for the development of 21st-century skills and competencies.

- TAEP4.0 as a support resource for training teachers to use the technological resources available at school.
- b) Realization of an SMS that indicates possibilities of work about Education 4.0 (Analyze stage of ADDIE).
- SMS to characterize studies that support the development of 21st-Century skills and competencies in the context of Education 4.0.
- SMS enabled: a) the definition of a protocol for conducting SMS that can be used or extended in new research on Education 4.0; and b) establishing a knowledge base on characteristics and possibilities of work in the context of Education 4.0.
- Possibilities of work about how to insert Computing and Informatics in Basic Education to promote Education 4.0.
- c) Elaboration of artifacts for planning, execution, and analysis of studies in the context of Education 4.0 (Implement and Evaluate stages of ADDIE).
- Artifacts for the use of TAEP4.0 and self-assessment of 21st-Century skills and competencies in the context of Education 4.0.
- Dissemination of knowledge through the publication of studies, including the assessment of TAEP4.0 acceptance.

## **6. Final Considerations**

This master's dissertation presented the TAEP4.0 (Teacher Assistance Educational Process) as a support to the Basic Education teacher in preparing classes in the context of Education 4.0. In this work, TAEP4.0 was evaluated, and also the projects generated through TAEP4.0. Thus, teachers, managers, and students participated in the studies giving their feedback. TAEP4.0 enables the use of technological resources to encourage 21st-Century skills and competencies. TAEP4.0 was developed with Google Sites technology, a free and structured tool that collaboratively allows the creation of web pages. Thus, TAEP4.0 enables the teacher to prepare practical, personalized, and interactive classes, focusing on 21st-Century skills and competencies. Following the steps of TAEP4.0, the teacher selects the information and the appropriate technology according to the school's reality, the discipline, and the needs of the students. For this, in each step of TAEP4.0, some materials available on the web were presented as a suggestion to streamline and facilitate projects creation.

### **6.2 Future Works**

Next, some future perspectives of this research are:

- a) Development of the TAEP4.0 platform
  - Create a platform of TAEP4.0 in which teachers can propose their projects and interact with students.
  - Allow the customization and adaptation of TAEP4.0 so that the teacher can omit or add steps, considering students' needs and the reality of the school.
- b) Possibilities for new scientific works
  - This dissertation can serve as a basis for the realization of new master's dissertations, graduation works, and doctoral theses. In addition, the work possibilities identified in this research about Education 4.0 can align and direction to educational proposals and practices in this context.



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