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A PEDAGOGICAL MODEL FOR INTEGRATING DIGITAL TECHNOLOGIES IN EDUCATION: WORKSHOPS ON SUSTAINABLE DEVELOPMENT GOALS (SDGS)

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ABSTRACT

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| Aim/Purpose | A proposal for a pedagogical model that integrates digital technologies in teaching Sustainable Development Goals (SDGs) in K-12 Education. |
| Background | The research is developed within project InTecEdu (Integration of Technology in Education), developed by the research group since 2008, and focusing on social inclusion for highly socially vulnerable K-12 students. |
| Methodology | The research was exploratory and qualitative; data was collected through a questionnaire and participant observation, with 253 students and 9 teachers from 5 Brazilian public schools. |
| Contribution | The research contributes by bringing a pedagogical model for integrating SDGs and Information and Communication Technologies (ICTs) in K-12 education. |
| Findings | All analyzed aspects received a high level of approval, although some opportunities for improvement were identified, such as the duration and frequency of the session. |

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| Recommendations for Researchers | We recommend the reuse of the pedagogical model, since our intention is for it to be open-source, and free to use. |
| Impact on Society | The paper is aligned with the fourth SDG: Quality Education. It directly contributes with the education of 253 socially vulnerable students from a south American public school, and indirectly contributes with improvement of education. |
| Future Research | To improve the pedagogical model based on the feedback from the questionnaires and apply it with a more extensive scenario. |
| Keywords | SDGs, digital information and communication technologies, pedagogical model, K-12 education |

INTRODUCTION

Teaching strategies in an educational setting are fundamental actions aimed at developing students' cognition, metacognition, and emotional processes (Moreira, 2014). The utilization of these strategies enables students to comprehend and construct knowledge with autonomy and responsibility. Thus, the teacher plays a crucial role in facilitating students' engagement in their own learning. This is primarily achieved when educators structure activities and the pedagogical environment in a dynamic manner, involving all participants (Moreira, 2014).

Camargo and Daros (2018) argue that pedagogical activities should be oriented towards reality and foster competencies that are beneficial for students' personal and professional fulfillment. In this way, students acquire the ability to construct knowledge that is applicable to their own contexts. Additionally, Camargo and Daros (2018) also highlight the importance of developing digital competencies, as they have become increasingly necessary in our society.

Digital competencies enable the implementation of Digital Information and Communication Technologies (ICTs) as contributing tools in this learning process (Muniz & de Oliveira, 2021). According to Bacich and Moran (2018), education needs to be reformulated by analyzing the contributions, risks, and changes arising from the interaction with digital culture, the interaction of ICTs, resources, interfaces, and media languages in teaching practice.

It is worth noting that pedagogical practices adopted with the implementation of ICTs in education enhance student engagement, enabling them to develop skills in planning processes and procedures related to their own learning. As a result, the interaction among students, teachers, and the school environment is transformed through the inclusion of technological resources, creating conditions for a mutual teaching and learning process between educators and learners (Zandvliet, 2012).

In this scenario, an important planning tool that assists in the development and execution of actions to integrate ICTs is the Pedagogical Model (PM). According to Behar (2009), the PM is a system of theoretical premises that represents, explains, and guides a curricular approach that is embedded in teaching practice and interactions among the teacher, student, and learning object.

The use of pedagogical models for integrating ICTs can contribute to students building the necessary technical knowledge to utilize these technologies. However, in order to effectively integrate with ICTs, it is crucial for the PM to place the student at the center of the learning process, enabling interaction with the world and the construction of knowledge through the opportunities offered (da Silva et al., 2021).

Pedagogical models are applicable to all areas of education, and it is even possible to work with PM in an interdisciplinary practice (Behar & Schneider, 2016). Therefore, an interesting approach for this research is the Sustainable Development Goals (SDGs), as according to UNESCO's definition (UNESCO, 2017a), interdisciplinarity is also embedded in global change issues.

The SDGs are part of the 2030 Agenda for Sustainable Development created by the United Nations in 2015, comprising a set of 17 goals with 169 targets and 230 indicators (de Carvalho, 2015). This agenda serves as medium and long-term planning tools that enable the alignment of social, environmental, and economic policies (Pimentel, 2019).

Brazil is a signatory to the 2030 Agenda, thereby committing to collaborative action with other countries to implement the Sustainable Development Goals. Although it is a global agenda, achieving the objectives and targets set by the SDGs requires the collective effort of municipal, state, and national governments, universities, businesses, civil society, among others (UNESCO, 2017a).

It is necessary to work, discuss, and reflect on content directly related to the common subjects of the curriculum, while generating actions focused on a global environment that promotes social equality, respect for the environment, access to economic, political, cultural, scientific, technological, and ethical growth and development.

Thus, the overall objective of this research was to develop a proposal for a pedagogical model to integrate digital technologies in teaching the SDGs in K-12 education, based on a literature review, to be more detailed on section 3.

Besides introduction, this paper is divided into 5 more sections: Literature Review (section 2), which presents the results from a literature review on pedagogical models and SDGs; Materials and Methods (section 3), concerning the methodology applied in this research; Results (section 4) presenting the results obtained in the research; Discussion (Section 5), which discusses those results; and finally, Conclusions (section 6), followed by the references used in the research.

LITERATURE REVIEW

This section presents a background on related work in the research area, and it is divided into 2 topics: “Pedagogical models and digital technologies”, and “Sustainable Development Goals”.

PEDAGOGICAL MODELS AND DIGITAL TECHNOLOGIES

The pedagogical model represents a theoretical system guiding curriculum approaches, manifested in educational practices and interactions among teachers, students, and the subject of study (Behar, 2009). This triangular relationship involves individuals as drivers within the defined model (Behar, 2009). The pedagogical model comprises the correlation between elements of Pedagogical Architecture (PA) – encompassing organizational, content, methodological, and technological aspects – and the Pedagogical Strategy (Behar, 2009).

PA is employed in the conception, construction, and organization of lessons, encompassing four aspects: Organizational (pedagogical planning), Content (topics presented), Methodological (how content is addressed), and Technological (utilization of resources and digital tools) (Behar, 2009).

Pedagogical strategies serve as a bridge between the defined pedagogical architecture and practical implementation in the virtual classroom (Behar, 2019). Developing a pedagogical model requires constructing a pedagogical architecture and defining key stakeholders, such as students, teachers, tutors, and administrators (Behar, 2019). It is important to note that there is no standardized pedagogical architecture, as it varies based on individual profiles and contextual considerations, allowing for customization to meet specific needs (Behar, 2019).

Sanders et al. (2019) conducted research on the Writer’s Workshop structure to create a framework supporting learning in a makerspace environment. This framework offers a customizable guide for teaching and learning STEAM content, adapted to the unique circumstances of different school environments, serving as an interdisciplinary initiative.

Avsec and Sajdera (2019) employed a pedagogical model for “engineering thinking,” akin to “design thinking,” with a focus on engineering concepts. Their study involved testing the model with 154 pre-school teachers from Slovenia and Poland. The authors aimed to enhance teachers’ creative potential and attitudes regarding technology use in schools.

Anthony et al. (2023) developed a pedagogical model to investigate factors influencing teachers’ behavioral intention and actual usage of hybrid learning modalities based on the Unified Theory of Acceptance and Use of Technology.

In conclusion, each pedagogical model possesses unique characteristics and benefits. It is crucial to select a model aligned with the demands of the contemporary world, promoting creativity, critical thinking, and student development. Bacich and Moran (2018) argue for reimagining education by analyzing the contributions, risks, and changes arising from interactions with digital culture and information and communication technologies within teaching practices. They emphasize the importance of integrating professional, cultural, and educational spaces to create authentic technology-based contexts.

Additionally, it is essential to not only integrate technologies into pedagogical models but also prioritize the inclusion of sustainable development goals as content, which will be discussed further in the following section.

SUSTAINABLE DEVELOPMENT GOALS (SDGs)

The convergence of science and technology has significantly expanded the capacity for innovation in societies. While in past decades, growth was primarily driven by the exploitation of natural resources and physical labor, the foundation for contemporary growth now depends on technological innovations and qualified labor, coupled with sustainable management (da Veiga, 2007).

The concept of sustainable management is a modern notion that emerged from discussions initiated at the Conference on the Biosphere in Paris in 1968 and the United Nations Conference on the Environment in Stockholm in 1972. Since then, the concept of sustainability has taken shape, leading to the emergence of a new paradigm known as the Triple Bottom Line or the Sustainability Triple Bottom Line. This concept, coined by British author John Elkington, suggests that organizations can achieve sustainability by considering the economic, social, and environmental aspects of their activities in a balanced and integrated manner (Elkington, 2001).

In this regard, the definition of sustainable development has been updated to include the United Nations’ Sustainable Development Goals (SDGs). The SDGs are part of a sustainable development agenda proposed by the United Nations in 2015. This agenda outlines 17 goals and 169 targets to be achieved by the year 2030 (UNESCO, 2017a).

The 17 Sustainable Development Goals are as follows: 1) No Poverty; 2) Zero Hunger; 3) Good Health and Well-being; 4) Quality Education; 5) Gender Equality; 6) Clean Water and Sanitation; 7) Affordable and Clean Energy; 8) Decent Work and Economic Growth; 9) Industry, Innovation, and Infrastructure; 10) Reduced Inequalities; 11) Sustainable Cities and Communities; 12) Responsible Consumption and Production; 13) Climate Action; 14) Life Below Water; 15) Life on Land; 16) Peace, Justice, and Strong Institutions; 17) Partnerships for the Goals (UNESCO, 2017a).

Achieving the SDGs requires collaboration among governments, businesses, and civil society, as all have important roles to play. In the long term, the SDGs represent a balance between the economy and the environment, which can be achieved by integrating and recognizing economic, environmental, and social issues throughout the decision-making process (Osorio Guzmán et al., 2020).

Education is not only an integral part of sustainable development but also a fundamental means to its realization. There is a responsibility to address sustainability issues and promote the development of relevant competencies to meet the challenges of education today (UNESCO, 2017b).

In conclusion, the Sustainable Development Goals are part of a clear agenda that has helped guide public policies, foster innovation, promote cooperation, and facilitate joint actions among governments, the private sector, academia, civil society, and citizens.

MATERIALS AND METHODS

This section outlines the methodological procedures employed for conducting this research. In terms of its nature, the research falls under the category of applied research, signifying a focus on in-depth investigations for problem-solving. Within this research type, it is possible to expand scientific knowledge and explore new, specific questions (Gil, 2017).

Regarding the approach to the problem, the research is characterized as qualitative. de Pádua (2019) emphasizes this approach as an alternative that allows for data collection from individuals in society, regardless of their educational level, and facilitates both quantitative and qualitative analysis.

Considering the objectives, the research is categorized as exploratory since its aim is to attain a deeper understanding of the defined problem, making it more apparent and enabling the construction of potential pathways to follow (Gil, 2017).

The technical procedures encompass the classification of bibliographic research, which will be further elaborated on in the literature review stage, and participant observation. The data collection technique of participant observation involves the active involvement of the researcher in the life of the community, organization, or group where the study is conducted. While maintaining certain boundaries, the observer assumes the role of a group member (Marconi & Lakatos, 2017).

Regarding the research question for this paper, it is formulated as “What pedagogical model can effectively integrate digital technologies into K-12 education to promote the understanding and implementation of Sustainable Development Goals?”.

The development of this research proceeded through the stages as shown in Figure 1.

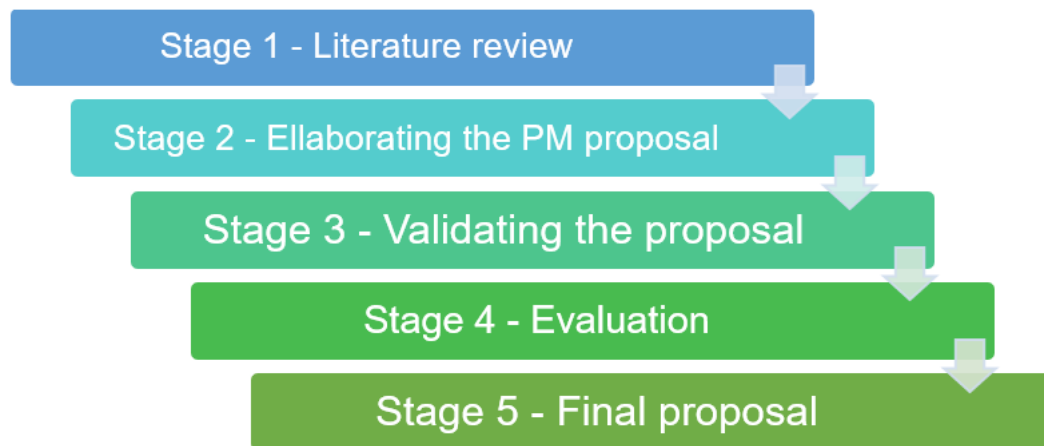


Figure 1: Research stages

STAGE 1—LITERATURE REVIEW

In order to achieve this stage, a theoretical foundation was developed to support the structuring of the pedagogical model for the integration of digital technologies on the SDGs in K-12 education. This review brought together the main research studies on the studied theme.

To identify the most recent works that present pedagogical models integrating ICT in K-12 education, searches were conducted for publications from January 2018 to June 2022. The databases used were IEEE Xplore, Scopus, and Springer, and the keywords included: “Pedagogical Model,” “Digital

Technologies” or “Digital Technology” or “ICT” or “Information and Communication Technologies” or “DICT” or “Digital Information and Communication Technologies,” and “K-12 education”.

Results from the Literature Review are presented in the Background section of this paper.

STAGE 2 – ELABORATING THE PM PROPOSAL

To accomplish the objective of this stage, a pedagogical model proposal was developed based on the framework advocated by Behar (2009), incorporating the following elements: the subject; pedagogical architecture (organizational, content-related, methodological, and technological aspects); and pedagogical strategy.

STAGE 3 – VALIDATING THE PROPOSAL

The objective of Stage 3 was to implement the proposed pedagogical model for the integration of the SDGs and ICT in K-12 education. Therefore, the decision was made to structure the workshops using the InTecEdu platform, developed and managed by the RExLab research group. The workshops followed a format in which students could actively interact, co-constructing the content with the teacher, fostering collaborative work and the exchange of experiences related to the SDGs, thus creating a mutual teaching and learning environment.

For this stage, the researcher sought out teachers interested in participating in the re-search through networking and referrals. The participating teachers and their respective students had their profiles created by the RExLab team.

During the implementation, the use of tablets or computers was included to facilitate student interaction with didactic sequences as supplementary materials to complement the knowledge acquired during the workshops. The participating teachers conducted the workshops according to their schedules or lesson plans, while the researcher, as a master’s student, participated through the participant observation method.

The workshops were implemented by 9 teachers in 5 different schools, covering 5 municipalities, and involving a total of 253 students.

STAGE 4 – EVALUATION

Stage 4 aimed to evaluate the workshop based on the proposed pedagogical model. This stage began with data collection through an online structured questionnaire (Google Forms) consisting of both open-ended and closed-ended questions. The questionnaire was sent to the teachers and had to be completed within one day after the workshops concluded. The closed-ended questions provided response options based on the Likert scale, aiming to establish a comparative parameter that would reflect the evaluation of the pedagogical model used to structure the workshops.

Subsequently, the analysis of the results was conducted by compiling the collected data, creating graphs, tables, a report, and discussing the results based on the existing literature.

STAGE 5 – PM FINAL PROPOSAL

The analysis conducted in the previous stage will enable an overall evaluation of the workshop and the development of a revised version of the Pedagogical Model that incorporates the improvements suggested by the teachers and observed by the researcher through the participatory method. The feedback provided by the teachers and the re-searcher’s observations will be carefully considered to enhance the Pedagogical Model and ensure its effectiveness in integrating the Sustainable Development Goals (SDGs) and Information and Communication Technologies (ICT) in K-12 education. The revised version will aim to address any identified limitations or areas for improvement to create an enhanced and more impactful educational experience.

RESULTS

This section presents the topics: “Pedagogical Model for the Sustainable Development Goals (SDGs) in K-12 education,” “Results of Workshops Based on the Proposed Pedagogical Model,” and “Proposal for a Pedagogical Model to Integrate Digital Technologies in Teaching the SDGs in K-12 education.”

APPLIED PEDAGOGICAL MODEL FOR INTEGRATING DIGITAL TECHNOLOGIES IN TEACHING THE SDGs IN K-12 EDUCATION

The applied pedagogical model was structured into “Subject,” “Pedagogical Architecture,” and “Pedagogical Strategy.”

The creation of the workshops based on the pedagogical model was facilitated by the online platform InTecEdu, a virtual learning environment provided free of charge by the Remote Experimentation Laboratory (RExLab). InTecEdu utilizes a MOODLE (Modular Object-Oriented Dynamic Learning Environment) environment and can be accessed on computers or mobile devices.

As mentioned earlier, the workshops were conducted by 9 teachers in 5 different schools, spanning 5 municipalities, and involving a total of 253 students. The distribution of the workshops by educational level was as shown in Table 1.

Table 1: Number of workshops applied per school level

| Schools | Primary school | Secondary school | High school |
|------------|----------------|------------------|-------------|
| School “A” | 1 | 0 | 0 |
| School “B” | 1 | 0 | 0 |
| School “C” | 2 | 2 | 1 |
| School “D” | 1 | 1 | 0 |
| School “E” | 0 | 0 | 1 |

The workshop developed with a focus on Elementary School 1 was conducted in different classes from December 2021 to August 2022. It was organized into four sections: “What are the SDGs? Getting to Know the SDGs,” “Applying the SDGs,” and “Support for Teachers.” These sections included videos, activities, games, reading materials, and other resources provided by the InTecEdu platform.

The workshops developed with a focus on Middle School and High School were conducted in 3 and 2 classes, respectively, from December 2021 to August 2022. They were divided into five sections: “What are the SDGs?” “Getting to Know the SDGs,” “SDGs in Brazil,” “Applying the SDGs,” and “Support for Teachers.” These sections also included videos, activities, games, reading materials, and other resources available on the InTecEdu platform.

RESULTS FROM THE WORKSHOPS

This section aims to present the results of the workshop applications. In order to collect the data analyzed below, questionnaires consisting of both closed-ended and open-ended questions were administered using the Google Forms tool.

Respondent profile

To better understand the profile of the respondents, a question regarding gender was structured, with response options: Female, Male, or Prefer not to answer. In total, 9 teachers conducted 10 workshop sessions. Among the respondents, 90% identified as female, while 10% identified as male.

The majority of the teachers fall within the age range of 41 to 50 years, accounting for 60% of the respondents. Another 30% of the teachers are in the age range of 31 to 40 years. However, only 1 teacher (10%) falls within the age range of 21 to 30 years, and none of the teachers are under 20 years old or over 50 years old.

Another aspect investigated was the educational level of the participating teachers. The results show that 80% of the teachers hold a specialist degree, while the remaining 20% hold a Master's degree. It is noteworthy that none of the teachers hold a Doctorate degree.

Data from applying the workshop

The data from the application were collected through three questions, the first of which was: "In what type of educational institution did you apply the workshop?". The data indicated that the vast majority of teachers, 9 out of 10, applied the workshop in public schools, while only 1 teacher applied it in a private school.

Regarding the grade level of application, out of the 10 workshop sessions, 5 were conducted in Elementary School Level 1, accounting for half of the sessions. Another 30% were applied in Elementary School Level 2, and 20% were applied in High School.

It was also important to understand the number of students who participated in the sessions. The 10 workshop sessions had a total of 253 participating students. Among these, three sessions were conducted with classes of 30 students, while the remaining sessions had class sizes of 10, 12, 16, 20, 23, 40, and 42 students.

Pedagogical model

This section will present the results related to the pedagogical model composed of the pedagogical architecture (including organizational aspects, content aspects, methodological aspects, and technological aspects) and pedagogical strategies.

Pedagogical architecture: organizational aspects. Regarding the objective of the workshop, the question asked was: "Do you consider the objective of expanding students' knowledge about the Sustainable Development Goals (SDGs) aligned with the National Common Core Curriculum (BNCC) to be relevant?" The responses followed a 5-point Likert scale.

The data shows that 70% of the teachers considered the objective of the workshop to be "Highly Relevant," while another 30% considered it "Relevant." No responses were recorded for the options "Neither relevant nor irrelevant," "Slightly irrelevant," or "Totally irrelevant." According to UNESCO (2017b), the BNCC guidelines state that curricula should incorporate various cross-cutting and integrating themes related to the SDGs, such as food and nutrition education, health, family and social life, science and technology, cultural diversity, among others.

The teachers were also asked about the proposed workload. The data indicates that although 60% of the responses were concentrated in "Strongly Agree" and "Agree," the remaining 40% deserve attention. The responses clearly indicate that the proposed work-load for the workshop was not sufficient, and this aspect should be reevaluated in the pedagogical model.

Another question investigated the use of the virtual platform as a means of conducting the workshops. The respondents (60%) fully agreed, while another 40% agreed. No responses were recorded for the other options. The results indicate the effectiveness of the proposed format, reaffirming the concepts and examples presented in the literature review on the integration of digital technologies in education. According to Viana et al. (2023), the use of digital platforms in K-12 education enables extensive interactivity and information exchange, which tends to facilitate collaborative knowledge acquisition and contribute to the evaluation of the teaching and learning process.

The research participants emphasized the importance of having a monitor's collaboration, especially to assist students in the login process on the InTecEdu platform. According to de Oliveira and Maziero (2013), a monitor is useful for the teaching process as they work together with the teacher, assist in didactic activities, and prepare and conduct practical work.

To facilitate the login process (which was indicated as difficult), especially when there is no monitor available to assist, the teacher can test the access in advance and demonstrate the login using a projector during the application.

Pedagogical architecture: content aspects. The data on content aspects were related to the relevance of the covered content (SDGs). Thus, it can be said that the chosen theme was appropriate, as 100% of the responses were concentrated in the options "Highly Relevant" and "Relevant." The urgency of the SDGs theme was addressed in the literature review; however, this does not prevent the possibility of considering the application of workshops with other content after validating the pedagogical model. UNESCO (2017b) highlights that one of the main objectives of bringing the SDGs theme to classrooms is to prepare students to act responsibly to ensure environmental integrity, economic viability, and a fairer and better society.

Brazilian K-12 education has a guiding document, the BNCC. Regarding this, teachers were asked if it was possible to relate it to the SDGs. In this regard, 50% of the teachers fully agreed, and the other 50% agreed. No neutral or disagreement responses were recorded. The level of approval for this question was expected, considering that one of the motivations for choosing the theme was the possibility of relating it to the thematic units of the BNCC.

Regarding the adequacy of content organization, there was a high level of agreement (90%). It is worth noting that there is room for improvement in content organization, as 50% did not fully agree that the organization was appropriate. The content and resources of the workshops directly impact the participants' interest, so their construction should occur collectively. It is not just about designing workshops for students but with students, respecting and prioritizing their contributions to the learning process (da Silva et al., 2020).

Pedagogical architecture: methodological aspects. The first question regarding the methodological aspects was related to the problem-based methodology used in the workshop, where students are actively engaged. In this regard, there was a high level of approval for the methodology used, indicating that its implementation can be replicated in other workshops. The problem-based learning approach is advantageous as it places the student at the center of the process, in a situation close to reality and without a ready-made answer, thus enhancing their reflective capacity (Borochovcicius & Tortella, 2014).

The relevance of games was also analyzed. The results indicate a 90% relevance of the proposed games. Therefore, it is understood that the memory game and the quiz, being classic games used in education, were a well-founded decision for their inclusion in this workshop. Prensky (2012) emphasizes the importance of combining learning and games to promote reflection and critical thinking, measure the progress of the student/player, and provide more accurate feedback.

The high approval rate (40%) indicates that the videos used contributed to the learning process. Activities are fundamental elements for applying the knowledge acquired by students in the workshop, and through them, the teacher identifies what the student has learned.

The evidence regarding these aspects of the pedagogical architecture points to a consensus on the relevance of the content, games, and activities. However, regarding the feedback that the forum did not allow activity posting, it is possible that the teacher did not pay attention to the instructions, as the forum tool in the InTecEdu platform allows interaction among participants and posting of files in various formats (Machado et al., 2021).

Pedagogical architecture: Technological aspects. Regarding the technological aspects, the use of the InTecEdu platform for conducting the workshop was analyzed, and there was some divergence

in the teachers' responses to this question. Only 20% considered the use of the InTecEdu platform as very easy, while another 40% found it easy, 20% neutral, 10% difficult, and the same 10% found it very difficult. InTecEdu is a learning support system executed in the virtual MOODLE environment, which, according to Perez et al. (2012), has good acceptance due to its ease of use and being open-source software. The usability of MOODLE systems is theoretically easy since they have a user-friendly and intuitive interface. It is worth noting that one way to mitigate the difficulties students face with InTecEdu is for the teacher to present the tool in advance, demonstrating its use and functionalities (da Silva et al., 2020).

It was also important to understand the teachers' perception of their use of the platform, and the majority (90%) indicated that it was easy or very easy. An important point to consider is that if teachers can easily use InTecEdu, which is the same platform used by students, it is expected that students will be able to use the platform more easily with the assistance of the teacher and/or supervisor.

The results of this question are directly linked to the technological availability of each school. It is important to emphasize that having a device connected to the internet is one of the requirements for using InTecEdu. The graph indicates that 60% of the applications used tablets, 50% used notebooks, 40% used computers, and 10% used Chromebooks. Another 40% used the (non-essential) support of a multimedia projector. It is important for schools to provide infrastructure that offers greater technological availability for pedagogical use, as Albino (2015) states, "[...] the greater the availability, the greater the chances of the school making extensive use of ICT."

In the workshop applications, 40% of the teachers rated the local connection as regular or poor. From the perspective of this research, there is nothing that can be done to solve this problem in schools.

Pedagogical strategies

Regarding the pedagogical strategies, the adequacy of the proposed number of 2 sessions was questioned. At least 60% of the responses indicate a disagreement with the proposed number of sessions. These responses clearly indicate that, similar to the previously discussed issue of workload, the proposed number of sessions for the workshop was not sufficient. Therefore, this aspect should also be reevaluated in the pedagogical model.

The investigation of the pedagogical strategies in the workshop included three open-ended questions, and the summarized results are presented in Table 2.

Table 2: Evidences about pedagogical strategies

| Question | Answers |
|---|--|
| Based on your experience, do you consider workshops in this format to be interesting as a pedagogical strategy for the students? Justify your answer. | "Yes. In this format, students have the opportunity to have the entire class presented and at their fingertips, as well as being able to study/complement classroom learning or engage in activities at their convenience at home." |
| | "Yes, it is a very interesting pedagogical strategy, especially due to the relevance of the content covered and the use of digital technological resources." |
| | "Yes. Workshop is a way to construct knowledge, with emphasis on action, without losing sight of the theoretical foundation. The workshop provides an opportunity to experience concrete and meaningful situations. In this sense, the methodology shifts away from the traditional focus on cognitive aspects of learning and incorporates action and reflection, |

| Question | Answers |
|--|---|
| | <p>becoming a space for continuous learning, exchange of information, and diverse experiences from daily life. Furthermore, workshops promote a democratic, participatory, and reflective dynamic that is based on the pedagogical process of linking theory and practice, without elevating the educator as the sole holder of knowledge.”</p> <p>“Yes, I believe that these types of workshops make the student an active participant in their own learning. Additionally, it provides autonomy for learning.”</p> |
| <p>In relation to Pedagogical Strategies, the implementation methods/actions of the workshop, provide an evaluation: the relevant aspects and those that should be readjusted based on the experience conducted.</p> | <p>“The initial access to the platform took a little longer. In the second meeting, access to the platform was faster. It was interesting to pause the video at various moments to explain in smaller sections. This approach kept the students more engaged with the content. Reading the text in different blocks by different students, with the teacher providing explanations after each block read. This was followed by activities that facilitated the internalization of the content.”</p> <p>“The relevant aspects are the integration of content with technologies, and the aspects that need to be readjusted include addressing students who have difficulties with technology, autistic students, and students in the process of literacy.”</p> <p>“The workshop is a simple and fun way to learn, as students access the content in a light and enjoyable manner.”</p> |
| <p>Did you create pedagogical strategies that were not included in the proposed workshop model? What were they? What were the reasons behind using these strategies?</p> | <p>“I followed the proposed model by providing explanations of the content in small blocks, either by pausing the video for explanation or by reading small blocks and providing explanations.”</p> <p>“The first meeting with the 2nd grade was very difficult because they are in the process of literacy. They couldn’t proceed with the readings, videos, and games, and us teachers couldn’t attend to everyone. They needed assistance from the moment of accessing, entering their username and password, and following the activities. So, in the next meeting, I booked the multimedia room and accessed the platform together with the students. I played the videos, read the texts with them, and each one played the games on the computer, sharing it with everyone through the multimedia projector. After that, we accessed the tablets for them to play and answer the quiz. This strategy was implemented with the 2nd-grade class, as some of them are not literate yet due to the pandemic. The 4th-grade class also needed help to access the platform, enter the password, and many of them asked for guidance to</p> |

| Question | Answers |
|----------|---|
| | proceed with the activities, but it was more successful overall.” |
| | “Yes, I used all the content from the platform to first create an explanatory lesson on the topic. Then, we had a reflective debate, and only at the end did we use the platform as a resource to reinforce and delve deeper into the subject.” |

The evidence presented supports the results shown in the graphs regarding the pedagogical strategies, reaffirming the positive evaluation of the workshops and the pedagogical model. In the following section, the overall evaluation of the workshop is presented.

PROPOSED PEDAGOGICAL MODEL TO INTEGRATE DIGITAL TECHNOLOGIES IN TEACHING THE SUSTAINABLE DEVELOPMENT GOALS (SDGs) IN K-12 EDUCATION

Therefore, after analyzing the results of the workshop implementations based on the pedagogical model, the final version for the PM (as presented in Table 3) was developed.

Table 3: Final Version of the ODS Pedagogical Model in K-12 education

| SUBJECT | |
|---------------------------------|--|
| Target audience | K-12 students |
| PEDAGOGICAL ARCHITECTURE | |
| Organizational Aspects | |
| Goals | To enhance students’ understanding of the Sustainable Development Goals (SDGs) aligned with the National Common Curricular Base (BNCC). |
| Workload | 4 hours per class |
| Format | In person |
| Content Aspects | |
| Content approached | <ul style="list-style-type: none"> • Sustainable Development Goals (SDGs) • Thematic Units of the National Common Curriculum Framework corresponding to the educational level and related to the SDGs. |
| Methodological aspects | |
| Methodologies used | Situation-problem |
| Activities | Reading and games |
| Evaluation | Discussion forum |

| Technological aspects | |
|-------------------------------|---|
| Technologies | Computers and, or mobile devices |
| Digital technologies | InTecEdu platform Access to the Internet |
| PEDAGOGICAL STRATEGIES | |
| Classes | Actions adopted |
| What are the SDGs? | <ul style="list-style-type: none"> ● Brief workshop presentation; ● Introduce the use and functionalities of the InTecEdu tool; ● Watch a series of introductory videos about the section; ● Watch an explanatory video about what the SDGs are; ● Read/explain the material available in the “Global Pact SDGs” link; ● Watch a playlist of videos titled “Getting to Know the 17 SDGs - IBGE Explains”. |
| Getting to know the SDGs | <ul style="list-style-type: none"> ● Watch an introductory video about the section; ● Reinforce content through a memory game (4 in total); ● Practice with the quiz “Zero Hunger and Sustainable Agriculture”; ● Practice with the quiz “Health and Well-being”; ● Practice with the matching game “Peace, Justice, and Effective Institutions”; ● Practice with the quiz “SDGs”. |
| SDGs in Brazil | <ul style="list-style-type: none"> ● Read the comic strip introducing the session; ● Read/explain the material available on the “Official Website - ODS Brazil” link; ● Practice with the “Snakes and Ladders” game; ● Engage in a forum activity “Finding Actions in Brazil”. |
| How to apply the SDGs | <ul style="list-style-type: none"> ● Watch an explanatory video about the section; ● Practice with the “Hidden Image” game; ● Engage in a forum activity “Sharing Knowledge”. Share an original photo or video on how to apply ODS in daily life. (The teacher can adapt the forum according to their strategy) |

Based on the teachers’ feedback, specific changes were made to the pedagogical model. These modifications included the addition of introductory actions and student orientation for using the InTecEdu tool. The proposed workload was also expanded, the forum was modified to allow the teacher the freedom to adapt it, and new games were included.

DISCUSSION

The discussion section aims to provide insights and analysis based on the data collected during the implementation of the pedagogical model for integrating digital technologies in teaching the Sustainable Development Goals (SDGs) in K-12 education. This discussion will focus on several key aspects, including the overall effectiveness of the pedagogical model, its organizational, content, methodological, and technological aspects, as well as the pedagogical strategies employed.

OVERALL EFFECTIVENESS OF THE PEDAGOGICAL MODEL

The results from the workshop applications demonstrate a generally positive evaluation of the pedagogical model. The majority of teachers found the workshops to be an interesting pedagogical strategy for students, highlighting the opportunity for active learning, digital resource utilization, and the relevance of the content.

However, a noteworthy point is that some teachers indicated the need for adjustments in terms of workload, indicating that the proposed number of sessions may not have been sufficient. This feedback emphasizes the importance of flexibility in the model to cater to the specific needs of different classrooms and students.

ORGANIZATIONAL ASPECTS

In the organizational aspects of the pedagogical model, the objective of expanding students' knowledge about the SDGs aligned with the National Common Core Curriculum (BNCC) was considered relevant by a substantial majority of teachers. This alignment with the BNCC is a critical factor, as it promotes the incorporation of cross-cutting themes related to the SDGs into the curriculum, enhancing students' understanding of these global goals.

The effectiveness of using the InTecEdu platform for conducting the workshops was demonstrated by a high level of agreement among teachers. This indicates the platform's potential in promoting interactive and collaborative learning, aligning with contemporary pedagogical principles.

Moreover, the importance of having a monitor's collaboration was emphasized, particularly to assist students with the login process on the InTecEdu platform. However, this finding underscores the need for effective teacher training and support to ensure a smooth learning experience for both educators and students.

CONTENT ASPECTS

The content-related aspects of the pedagogical model received positive feedback. Teachers found the chosen theme, the SDGs, to be highly relevant, aligning with the urgency of educating students about these global challenges. Additionally, teachers perceived a strong correlation between the SDGs and the thematic units of the BNCC, reinforcing the model's alignment with the national curriculum.

While most teachers agreed on the content's relevance and organization, some room for improvement was identified in content organization. The feedback underscores the importance of collaborative content development and the involvement of students in the learning process.

METHODOLOGICAL ASPECTS

The methodological aspects of the pedagogical model, which included problem-based learning, games, and videos, were generally well-received. Problem-based learning, in particular, was highly favored, indicating its potential for student engagement and reflective capacity.

The use of games and videos was also seen as beneficial for the learning process, providing interactive and enjoyable experiences. These findings support the idea of combining learning with games to promote reflection and critical thinking, aligning with modern educational theories.

TECHNOLOGICAL ASPECTS

In the technological aspects of the pedagogical model, the use of the InTecEdu platform showed some divergence in teachers' responses. While a majority found it easy to use, a notable portion encountered challenges. It is essential to ensure that teachers and students are well-prepared and comfortable with the platform to maximize its benefits.

The type of devices used for accessing the platform varied, with a preference for tablets and laptops. These findings underscore the importance of schools providing adequate technological infrastructure to support pedagogical use.

PEDAGOGICAL STRATEGIES

The pedagogical strategies used in the workshops received positive feedback from teachers. They considered the workshops as interesting pedagogical strategies that empowered students to be active participants in their learning. The flexibility of the model allowed for adaptations based on the needs and characteristics of different classes.

However, some teachers found that the proposed number of sessions was insufficient. This highlights the need for flexibility in the model to cater to the varying needs and learning paces of students and classes.

FINAL VERSION OF THE PEDAGOGICAL MODEL

The final version of the pedagogical model reflects the adjustments made based on teacher feedback. It offers an organized structure that includes the target audience, pedagogical architecture (organizational, content, methodological, and technological aspects), and pedagogical strategies. The flexibility and adaptability of the model are key features that accommodate the diverse needs of K-12 students and teachers.

In conclusion, the results from the workshop implementations provide valuable insights into the effectiveness of the proposed pedagogical model for integrating digital technologies in teaching the SDGs in K-12 education. The positive feedback and areas for improvement identified in this discussion section contribute to the ongoing refinement and enhancement of the pedagogical model, ensuring its applicability and impact in diverse educational settings.

CONCLUSIONS

The objective of this research was to develop a proposed pedagogical model for integrating digital technologies in the teaching of the Sustainable Development Goals (SDGs) in K-12 education. The educational platform InTecEdu was utilized for this purpose.

The results of the workshops based on the proposed pedagogical model indicate its effectiveness. Various aspects, including organizational, content-related, methodological, technological, and pedagogical strategies, were evaluated and received high levels of approval and positive feedback. Some areas for improvement were suggested by the teachers or identified through result analysis. However, it is believed that these can be addressed in future applications and when replicating the pedagogical model in other knowledge domains.

Overall, this research contributed to identifying key and recent studies on pedagogical models linked to digital information and communication technologies. It also involved applying the pedagogical model as a proposal for integrating digital technologies in teaching the SDGs in K-12 education.

Given the positive perception of the teachers regarding the effectiveness of the pedagogical model, it is suggested that future research evaluates the students' perception when exposed to the workshops. Furthermore, replicating this pedagogical model in other contexts and knowledge areas is also recommended.

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