Development of personal and interpersonal skills in applying the Design Thinking methodology to climate change issues[1]

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ABSTRACT

Climate change has been widely debated at both national and international levels, highlighting concerns about sustainable development and environmental protection. This study, an excerpt from a dissertation, analyzes how Design Thinking in the classroom promotes personal and interpersonal skills in High School students. Through a qualitative approach with an exploratory objective, after developing the didactic strategy, relating DT to the theme of climate change, DT's six steps were applied with third-year high school students. The results show that the methodology, used with its learning tools, develops and strengthens skills such as empathy, creativity, group work, decision-making, and problem-solving, among others, becoming a strong ally in the treatment of themes such as climate change, as it has great potential to promote active and collaborative learning.

KEYWORDS: Design Thinking; Interpersonal skills; Active methodology; Climate change.

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Desenvolvimento de habilidades pessoais e interpessoais na aplicação da metodologia do Design Thinking em questões sobre mudanças climáticas

RESUMO

As mudanças climáticas têm sido amplamente debatidas em nível nacional e internacional, destacando a preocupação com o desenvolvimento sustentável. Este estudo, recorte de uma dissertação, analisa como o Design Thinking em sala de aula favorece habilidades pessoais e interpessoais em estudantes do ensino médio. Por meio de uma abordagem qualitativa, com o objetivo exploratório, após a elaboração da estratégia didática, relacionando o DT a temática de mudanças climáticas, houve a aplicação dos 6 etapas do Design Thinking com estudantes do terceiro ano do ensino Médio. Os resultados mostram que a metodologia aplicada com suas ferramentas de aprendizagem, desenvolvem e fortalecem habilidades como empatia, criatividade, trabalho em grupo, tomada de decisão, solução de problemas, entre outras, se tornando uma forte aliada ao tratamento de temas como mudanças climáticas uma vez que apresenta grande potencial para promover uma aprendizagem ativa e colaborativa.

KEYWORDS: Design Thinking; Habilidades interpessoais; Metodologia ativa; Mudanças climáticas.

Desarrollo de habilidades personales e interpersonales en la aplicación de la metodología Design Thinking a temas de cambio climático

RESUMEN

El cambio climático ha sido ampliamente debatido a nivel nacional e internacional, destacando la preocupación por el desarrollo sostenible. Este estudio, extracto de una disertación, analiza cómo el Design Thinking en el aula promueve habilidades personales e interpersonales en estudiantes de secundaria. A través de un enfoque cualitativo, con objetivo exploratorio, luego de desarrollar la estrategia didáctica, relacionando la DT con la temática de cambio climático, se aplicaron las 6 etapas del Design Thinking con estudiantes de tercer año de secundaria. Los resultados muestran que la metodología aplicada con sus herramientas de aprendizaje

desarrolla y fortalece habilidades como la empatía, la creatividad, el trabajo grupal, la toma de decisiones, la resolución de problemas, entre otras, convirtiéndose en un fuerte aliado en el tratamiento de temas como el cambio climático ya que tiene un gran potencial para promover el aprendizaje activo y colaborativo.

PALABRAS CLAVE: Design Thinking; Habilidades interpersonales; Metodología activa; Cambio climático.

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Introduction

In 2015, the United Nations (UN), in partnership with Brazil and the representatives of member states of the UN General Assembly, created the Sustainable Development Goals (SDGs). According to the UN (2015), these goals are a global call to protect the environment and climate and eradicate poverty. The 2030 Agenda is an action plan. It has a set of 17 Sustainable Development Goals and 169 targets, which will be in force for 15 years, from January 1, 2016, to 2030.

Specifically, SDG Goal 13, which addresses Climate Action, aims to take urgent action to combat climate change and its impacts. The need for environmental education focused on climate change has become increasingly evident due to the significant rise in extreme weather events, loss of biodiversity, changes in food production, and other environmental issues related to climate change. In this sense, addressing the issue of climate change in schools becomes a crucial topic to meet the demands presented by society today, to develop attitudes favorable to environmental sustainability.

To address topics such as climate change in the classroom, it is essential to incorporate new teaching methodologies that enable students to become active participants in their own teaching-learning process and develop personal and interpersonal skills in addressing the topic.

According to Morán (2015), active methodologies function as a starting point that leads to more advanced processes of reflection, cognitive integration, generalization, and reconstruction of new practices, in which the student is active when placed at the center of the teaching and learning process and invited to reflect and act on problems that make sense to him. Thus, the student can act autonomously, while the teacher is the guide of the process, responsible for directing the student (Leite, 2021).

Therefore, aiming to contribute to the proposals presented by active methodologies and meet the educational demands of forming a student capable of living in society, it is understood that discussions are necessary on how to approach these methodologies in the educational context. One of the active methodologies that can contribute to the construction of students' knowledge and the development of skills necessary to live in society is Design Thinking (DT).

What is Design Thinking?

Design Thinking, or DT, is considered an active methodology that, in the educational context, promotes student engagement and autonomy. According to Cavalcanti and Filatro (2016), as a teaching and learning strategy, DT can facilitate and contribute to the development of interpersonal skills (soft skills) such as creativity, empathy, group work, and collaboration among those involved.

Methodologies need to reflect the objectives set by teachers, the common curricular bases, and school programs, as well as the transformations society is undergoing. Therefore, "active methodologies are starting points to advance to more advanced processes of reflection, cognitive integration, generalization, and reworking of new practices" (Morán, 2015, p. 18, our translation). Furthermore, for Leite (2017, p. 1, our translation), active methodologies "enable the valorization of the critical and reflective training of the student who participates in the construction of their knowledge, in the teaching and learning process,

favoring their autonomy". Corroborating with Leite (2017) and Móran (2015), Berbel (2011) states that active methodologies are based on strategies to stimulate learning through real or simulated situations, preparing students to successfully resolve the challenges present in fundamental activities of life in society across various contexts.

DT is presented within this perspective as an active methodology that comes to the classroom with the proposal of promoting student engagement and active participation. In addition to enabling a deep and critical understanding of the topic addressed in its stages, it brings the strengthening and development of personal and interpersonal skills such as empathy, collaboration, creativity, and teamwork.

According to Cavalcanti and Filatro (2016), Design Thinking has three possibilities of application in the educational field. DT, as an "Innovation Approach," is focused on the results of implementing innovations. This implies that DT in this approach can focus more on the final products or solutions created, and that it significantly improves the innovation process.

As a "Problem-Solving Methodology," DT focuses on the efficient resolution of a problem or complex problems. In this application, DT proves efficient, as its phases involve the exercise of the empathy map, which helps people better understand the needs, motivations, and contexts of the people involved in the problem.

As a "teaching-learning strategy", DT is "opposed to traditional methodologies. It allows students to work in groups and creatively design solutions to real-world issues, identifying them in a specific context" (Silva Neto; Leite, 2023, p. 3, our translation). Thus, in DT as a teaching and learning strategy, students not only have the possibility of proposing solutions to an identified problem, but also of prototyping them (Cavalcanti; Filatro, 2016). In this case, DT is directed towards the classroom, where the students truly assume the role of protagonist: they are autonomous and assume their responsibilities, and they are also encouraged to experiment, create, and explore. To use DT as a teaching and learning strategy, it is

necessary to articulately integrate the elements that compose the educational process, teaching-learning, and assessment.

In short, for Cavalcanti and Filatro (2016), a project can be developed with only one of the three applications; however, it is possible to find elements of all of them in the solutions and experiences lived by design thinkers. Therefore, they are correlated with each other.

In addition to presenting three possible applications in the educational context, Design Thinking presents some steps discussed in the literature. In this study, the steps were reorganized and adapted to the propositions by IDEO (2009), Educadigital Institute (2014), and Cavalcanti and Filatro (2016), to better apply and adjust the methodology in the classroom, aiming to address the application time and the structure and dynamics of school reality.

The table below presents the steps used and the steps taken in each stage of the DT.

**Table 1** - Adaptation of the DT steps/phases

STEPS	PHASES
Discovery	• Defining the Strategic Challenge - Discovery • Organizing Prior Knowledge • Data Collection Plan
Interpretation	• Empathic Interview - Interpretation • Interview Data Analysis • Empathy Map • Persona Creation
Ideation	• Refining the Problem - Ideation • Brainstorming • Choosing the Best Ideas
Prototyping	• Rapid prototyping • Prototyping
Implementation	• Implementation plan
Evolution	• Feedback • Learning plan

Source: Authors (2024).

In the first stage, Discovery, the challenge has to be defined and then delimited. The organization of prior knowledge and the organization of exploratory research are also presented. The choice of challenge must meet characteristics, such as a contemporary theme, and it must be present in students' daily lives, be shaped in human terms, comprehensive, and specific at the same time. In this study, the strategic challenge chosen and presented was: *How can we reduce the impacts of climate change on Earth?*

The second stage, Interpretation, is where the student can approach people who are related to the strategic challenge, identify crucial aspects, and, most importantly, develop empathy. Students are immersed in the strategic challenge, developing empathetic interviews and interpreting the data obtained through the data collection plan. In addition to data collection, this stage involves analyzing the data obtained in the previous step. Students group to discuss the data collected and, finally, create an empathy map. According to Silva and Gomes (2020, p. 6, our translation), the empathy map "is a DT tool, considered the most important, as its use aims at the initial stages of the process." Empathy is the ability to put yourself in someone else's shoes and understand their reality without judgment or bias. According to Cavalcanti and Filatro (2016, p. 169, our translation), the empathy map "helps to see the problem from the other person's perspective, and in this way, imagine what they think and feel in relation to the strategic challenge." This tool can be integrated with other teaching methodologies to facilitate the learning process of specific content, making the class more meaningful for students. Figure 1 presents an example of the empathy map and four keywords: What the person says, thinks, does, and hears in relation to the strategic challenge.

Figure 1 - Example of the empathy map
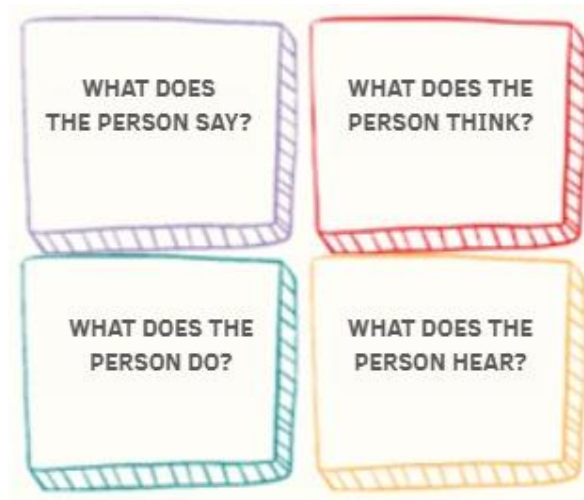
Source: Authors (2024).

In addition to the empathy map tool, this step involved creating a persona, a tool that is created when extracting and interpreting data (Lessa, 2024). The personas are representations that, in the teaching and learning process, are configured as the ideal person, a person immersed in the problem investigated. According to the information collected in the empathy interviews and the empathy map, the construction of the persona by the students becomes interesting, considering that they will specify the person immersed in the problem. According to Melo and Abelheira (2015), the purpose of the persona tool is to design a typical person immersed in that problem, who is part of a group, organization, or community.

In the third step, Ideation, several ideas are formulated to solve the strategic challenge. After the empathy map, students are directed to the brainstorming moment. In the first stage of this step, quantity is better than quality. According to Bolsonello et al. (2023), brainstorming in the school context aids the construction of knowledge in the classroom. Osborn (1987), creator of this tool, highlights that one of the principles is "appreciating creative ideas." Therefore, some researchers consider this tool to be a creativity tool. Santo (2015) states that its use becomes mandatory for those who want to be creative; it is a fundamental practice

to expand our vision in any area. After the brainstorming session, students, in groups, choose the best ideas to solve the proposed problem; these ideas must meet the fundamental criteria of the DT, which is selecting the most practical and innovative.

In the fourth stage, Experimentation, students are guided to do rapid prototyping, which aims to quickly prototype and test the ideas chosen in the previous stage, and which can be done in several different ways, such as sketches, drawings, flowcharts, mind maps, theatrical plays, digital material, mockups, models, stories, and advertisements, among others. At this stage, they will bring their ideas to life.

The fifth and sixth stages in DT, Implementation and Evolution, encompass the process of developing and improving knowledge, science. It is the development of the prototype over time. At this stage, several steps are taken, such as evaluating the development of your project, identifying the impacts caused by it, designing an implementation plan that follows four commands to be answered by the designs, namely: why it will be done, how it will be done, forecast of when it will be done and who will do it, in addition to involving people close to the strategic challenge, promoting their idea, creating partnerships and sharing their story. This stage focuses on the future of the chosen ideas, their maintenance, development, applicability, and practicality.

The steps and stages presented and chosen were based, adapted, and integrated to achieve the research objective, as well as to better adapt to the reality of the school where it was applied.

DT + personal and interpersonal skills

According to Borges (2022), interpersonal skills are related to the way a person deals with others and their emotions. Generally labeled as soft skills or behavioral skills, these skills are developed in the environment in which individuals find themselves, and, because they are

subjective skills, their development is more difficult. Lopes (2021, p. 5, our translation) afirms that Interpersonal skills are "non-cognitive skills that individuals need for good social relationships in the workplace." In 2004, Mertens introduced the concept of interpersonal skills as skills that are not related to an individual's technical training, but that contribute to their adaptation to the context in which they find themselves. These include: creativity, collaboration, empathy, communication, negotiation, decision-making, persuasion, ethics, and leadership, among others. There are also personal skills, also called hard skills or technical skills, which are skills typically assigned in an individual's training process, associated with a particular profession, and are generally curricular skills. These include: technical skills in specific content, ability to memorize, perform calculations, understanding the topic in question, skills in other languages, among others. Even with the differences between skills, it is crucial that individuals are able to develop them at the same rate. Therefore, according to Sydorenko (2020), it is essential that individuals have training that allows them to develop both skills to have the possibility of improving their living standards. However, it is necessary to consider that the development of such skills is continuous and often not immediate. Therefore, it is imperative to articulate methodologies that allow development not only at one level of education, but at all levels.

Table 2 - DT steps and articulation with personal and interpersonal skills

Steps	Stages	Interpersonal Skill	Personal Skill
Discovery	Strategic Challenge C.P. Organization Data Collection Plan	Motivation	Technical competence/ memory/understanding of content
Interpretation	Empathetic Interview Data Analysis Empathy Map	Empathy Communication	Technical competence/ memory/understanding of content
Ideation	Refine the problem Brainstorming Best idea selections	Creativity Negotiation	Technical competence/ memory/understanding of content
Prototyping	Rapid prototyping Testing	Team development	Technical competence/ memory/understanding of content
Implementation	Implementation Plan Implementation	Communication Teamwork Decision Making	Technical competence/ memory/understanding of content
Evolution	Feedback Analysis Learning plan	Conflict Management Self-Assessment	Technical competence/ memory/understanding of content

Source: Authors (2024).

Table 2 presents the articulation of DT with the possibility of developing and strengthening personal and interpersonal skills at each stage of its application, proposed by the authors of this article.

From the perspective of using DT as a teaching strategy, its steps strengthen personal skills and, when considering real and impactful situations, highlight the socio-environmental demands and the relationship between education, active methodologies, and the environment.

Climate change and its teaching

Given the intense climate variations and the increase in associated problems, such as global warming, the inclusion of the topic of climate change in the school context becomes crucial to respond to the contemporary demands of society, promoting the formation of conscious attitudes focused on preserving and improving the planet's environmental conditions.

Global warming, characterized by an increase in the planet's average temperature, is one of the main challenges associated with climate change.

This phenomenon triggers a series of interconnected consequences, including rising sea levels, reduced water availability, damage to agriculture, impacts on traffic routes, and risks to human health. Such impacts highlight the severity of the climate crisis and the urgent need for mitigating and adaptive actions on a global scale.

According to the UN (2023), climate change is a long-term transformation in temperature and weather patterns. Even though the changes are due to natural causes, since 1800 these patterns have been transformed and intensified by human actions. Specifically, the Paris Agreement, signed in 2015, represents the latest global effort to combat climate change. This international treaty brings together nearly 200 countries with the common goal of reducing greenhouse gas emissions and limiting global temperature rise. Therefore, Zezzo and Coltri (2022, p. 3, our translation) point that

> The most recent data from IBGE (2019) demonstrate that, despite educational initiatives on environmental education and even education on climate change, it is crucial to highlight that, in Brazil, there are still profound problems regarding education, concerning the essential, which is access to quality education. (Zezzo; Coltri, 2022, p. 3, our translation)

According to Monroe et al. (2019), among the difficulties teachers face in teaching about climate change, the preeminent difficulty is finding strategies for choosing and/or defining a methodological approach to adopt in the classroom. Another point is the excess of (mis)information, which compromises the development of interdisciplinarity inherent to the study of climate change.

Thus, Faria, Ramos, and Coltri (2021) state that teaching about climate change must be based on active pedagogical practices, which integrate teaching and learning processes, as well as the use of resources and

methods that promote interdisciplinarity, as only in this way is it possible to avoid a one-dimensional and abstract approach.

In this context, the Chemistry discipline appears as a relevant possibility for teaching climate change, since, as Rocha (2021, p. 596, our translation) highlights: "It is possible to promote Environmental Education within Chemistry classes by addressing various topics from the basic curriculum, precisely because this area of science has ties to different polluting causes due to human action." Miranda (2018) highlights that addressing environmental education in Chemistry implies promoting an approach that connects chemical content with global environmental problems, encouraging a deeper understanding and more conscious action for the students.

That said, it is necessary to promote an environmental education committed to social transformation, critical, interdisciplinary, and socio-environmental reflection, capable of developing skills in students and teachers so that they can act in the environment in which they live. Thus, the articulation between Chemistry teaching, environmental education focusing on climate change, and the DT methodology is an alternative to achieve these objectives.

Application of DT as a teaching and learning strategy

This research adopted a qualitative approach, corroborating Minayo and Sanches (1993), who affirm that a good method allows for the correct construction of data and helps to reflect on the theory, in addition to being feasible.

This research was conducted at a Reference High School (in Portuguese, *Escola de Referência no Ensino Médio*, EREM) in the public network. The research participants were 18 students enrolled in the third year of high school, class C, aged between 16 and 18 years old. We chose this

grade because we understand that these students should already have basic knowledge to develop the theme of climate change.

Based on the structural organization of Design Thinking proposed by Cavalcanti and Filatro (2016), IDEO (2009), and Instituto Educadigital (2014), this research was based on six main steps chosen and organized as follows: Discovery, Immersion, Ideation, Experimentation, Implementation, and Evolution, as previously mentioned.

Step 1 of Design Thinking (DT) – Discovery. The strategic challenge proposed to be addressed in the classroom was: "How can we reduce the impacts of climate change on Earth?" This challenge focuses on identifying and exploring actions that can be developed to mitigate the adverse effects of climate change, aiming to promote sustainable and environmentally conscious solutions.

Following the presentation of the strategic challenge, students individually answered a questionnaire about their prior knowledge (Appendix A). Table 3 presents the questions about prior knowledge.

Table 3 - Questions about prior knowledge

1. Do you feel part of nature?
2. How important is it to study climate change?
3. Do you know what global warming is and how it happens?
4. What is the greenhouse effect?
5. What damage can climate change cause? And which people or what are most affected?
6. Do you think your actions contribute to climate change? Which ones?
7. Who do you think is responsible for climate change?

Source: Authors (2023).

The answers helped in the construction and preparation of subsequent classes, and helped to identify the levels of knowledge on the topic presented in class.

Step 2 – Immersion. After completing the prior knowledge questionnaire, the 2nd meeting took place. Initially, the students watched two videos about climate change produced by the United Nations and

available on YouTube (https://www.youtube.com/shorts/DPXJUApZfy4 and https://www.youtube.com/watch?v=l19WLdf_NLo). We then discussed the general ideas from the videos and the quiz questions about prior knowledge. The debate lasted about 30 minutes. Finally, we held an expository/dialogue class on what climate change, global warming, the greenhouse effect, and gas emissions are.

In the third class, the students were divided into four groups to work together until the end of the methodology application. After forming groups, students chose a leader, and everyone had access to their logbooks. In this meeting, "who" or "what" are most affected by global warming were discussed, and from this discussion, they developed ten questions for the development of the empathetic interview. After constructing these questions, we guided the students on how to conduct an empathetic interview. The students chose the environment and time to conduct the empathetic interview; each group brought responses from three interviewees.

In the fourth class, we held a conversation about the results of the empathetic interview. The guiding questions asked by the researcher were: a) How did you feel when you did the interview? b) Was it difficult to do the interview? c) What was the best and worst part of the interview? d) Tell us a little about the data you collected. After this dialogue, the students worked in groups to create an empathy map and persona with the researcher's guidance. After building them, the students were guided to the next step.

Step 3 – In the brainstorming session and individually, they brought at least three ideas to combat climate change. In the fifth class, they exposed their ideas and discussed them to refine the problem and return to the initial challenge. After this moment, the students had more time to think of other solutions, this time in groups and in the classroom.

In the sixth class, the students, as a group, chose the best idea, also based on the persona, to start prototyping, according to its viability, economy,

and practicality. And they began rapid prototyping, noting the strengths and weaknesses and creating an action plan for prototype development (creation time and materials).

Step 4 – Prototyping. In the seventh class, the students began prototyping the chosen idea. This phase took place at school (during the class) and in another environment/time.

Steps 5 and 6 – Implementation and Evolution. In the ninth class, the students presented the prototype implementation plan and the prototype, and listened to feedback from the large group.

Reports and reflections based on the DT strategy and personal and interpersonal skills

In the discovery step, after the strategic challenge was presented ("how can we reduce the impacts of climate change on Earth?"), students demonstrated interest and curiosity about what they could do and what the next steps would be. The moment of reflection and concern encouraged dialogue about climate change, global demands, and concerns about its impacts.

According to Martinelli and Genari (2009), the motivationally oriented student is more interested in studying, starting an activity, and staying with it until the end.

In the second step (Interpretation), after the students participated in the interviews, each group had a talk with the researchers about their perception during the interview. Table 4 presents some of the groups' responses to the questions asked at this step.

Table 4 - Answers about the empathic interview

Question	Group	Answer
How did you feel doing the interview?	Group 2	*"I felt important (laughs), I found it very interesting, we were excited."*
Was it difficult to do the interview?	Group 4	*"I think I have difficulty, but since I was with the group, it was easier to approach and ask questions. And we also prefer to interview the school students."*
What are the best and worst parts of the interview?	Group 1	*"There wasn't a bad part. There was a proposal to invest in municipal laws and intervene concretely. It caught our attention because we think this already exists, but we don't see concrete punishments for those who break the law."*

Source: Authors (2024).

The responses obtained demonstrate the expansion of understanding on the subject when students can understand what others say and think. When they begin to relate the "abstract" concept of climate change to concrete problems in their reality, or when they realize the importance of environmental education in schools and also the need to talk about the topic, it emphasizes that it is vital to reduce the distance between their reality and the applied content, leading the students to perceive natural phenomena, understand them and feel capable of intervening in the problem (Sales; Silva, 2010).

At this step, the students were motivated and involved, jointly overcoming difficulties such as initial shyness, embarrassment, and nervousness. The possibility of interacting with several people from the school context itself provided space to understand what other people think and understand about the subject. Teamwork was crucial to overcoming the difficulties of this step; leading the discussions and the students' presence with each other was a real help for them, as they were able to feel more secure and confident when conducting the interviews.

After talking with the students, each group organized itself to create the empathy map and persona. Figure 2 represents the empathy map the groups made; the responses were grouped in each question.

Figure 2 - Empathy Map Responses

What does the person say?	**What does the person think or feel?**
G1 - Schools have a very important role in combating climate change G2 - The state and politicians need to put more effort into the laws G3 - Even though they know so much, they talk more about the city's climate G4 - They would like to know more about climate change and how they can help	G1 - Sometimes people are angry and don't realize what's going on. They're very worried. G2 - Distrust and fear that something worse will happen soon G3 - Concern that it be resolved before the worst happens G4 - That humans are the biggest culprits. Not just politicians, but everyone
What does the person hear?	**What does the person do?**
G1 - Sometimes we hear that this doesn't even exist. Unfortunately G2 - People don't care much about it because they may not realize the severity of it G3 - That will only change when the laws are enforced G4 - They don't usually hear much about the topic, and they think this is a problem	G1 - They like to include the topic in their classes G2 - They try to discuss the topic G3 - They try to do at least their part to help the environment G4 - They don't do much; they try to do the basics

Source: Authors (2024).

The empathy map shows how students achieved their ability to synthesize information. According to IDEO (2014), the empathy map technique enables a deep understanding of the problems and reality of the people for whom someone is projecting. The empathy map helps create solutions where the design team can combine their experiences with the real needs of people immersed in the problem. To "learn how to learn," we must stimulate curiosity and interest in participating in the construction of knowledge. The simple transmission of information does not enable intellectual development. First, it is necessary to "learn to feel" and then "learn to think" (Toro, 2002).

With the empathy map and persona construction by the groups, the students were able to problematize reality and define their personas based on the interviews, the construction of the empathy map, and the class discussions held during the discovery and interpretation steps. According to Melo and Abelheira (2015), constructing a persona enables students to understand people, their desires, those who may be most affected by the problem in question, and also the issues of stereotypes embedded in society as a whole.

In the third step, ideation, students searched and tried to solve various problems caused by climate change. Table 5 presents some of the problems and their solutions encountered by the student groups.

Table 5 – Brainstorm

Group	Issue	Solution
G1	Extreme weather events	Have projects such as rain gardens, linear parks, hillside restoration, and invest in urban agriculture.
	Environmental awareness	Using different methodologies to talk about environmental education and inform students.
G2	City floods	Investment to clean rivers with robots or people and raise public awareness.
	Problems in agriculture and food	Create community gardens and vegetable gardens in schools, neighborhoods, and communities.
	Risk alert	Use technology to alert communities to risks of flooding, high temperatures, landslides, or road problems, as well as information to combat climate change, especially in rural areas of the city.
G3	Floods due to rising sea levels caused by melting glaciers	Investment in the transposition of nearby rivers.
	Health problems	Create a virtual system that is efficient and alerts the population.
	Lack of plantations	Create projects that encourage the public to plant trees in the city, along riverbanks, and to preserve the environment. In addition, increase the maintenance of these areas.
G4	Impact on agriculture	Public awareness process regarding deforestation, pollution, and fires, emphasizing the importance of reporting and complying with laws.
	Lack of green areas	In the city, they can build green roofs with cisterns to absorb and capture rainwater.
	School participation in projects also in the city	Host events with student leaders and promote replanting in areas of the city during elective courses. These actions would be publicized on social media and other media outlets to raise awareness and encourage other schools and institutions.

Source: Authors (2024).

In this step, students talked among themselves to come up with creative and sustainable solutions. After the brainstorming session, the groups were able to return to their personas and modify or adjust them according to everything seen in this step because, according to Osborn (1987, p. 242), "The creative process doesn't end with the idea – it only begins with it". They came up with creative solutions and developed negotiation skills when they had to decide among themselves which idea would be prototyped and developed.

In Step 4, prototyping, the students chose the best ideas to solve the problem the personas they created had. The prototyped ideas resulted in practical and visual solutions such as a mockup, a brochure, and a game.

Group 1 developed a mockup faithful to the EREM Cardeal Dom Jaime Câmara, with dimensions and appearance similar to the school, and modifications to solve the temperature issue at the school. They suggested installing air conditioning in all the classrooms or improving the efficiency and number of fans.

Group 2 developed a game available on the Play Store, an Android system application, where they created a city with several environmental problems. The objective of the game is to make this city as clean as possible. It had selective collection, sanitary landfills, solar energy, hydroelectric plants, and its own plantations.

Group 3 created a mockup presenting the before and after of the road that connects the rural area of the municipality of Moreno with the urban area, demonstrating the benefits that this change can bring to people's lives without completely destroying the environment.

Group 4 developed a folder to deliver to the school and local community. The pamphlet contained questions and answers on the topic of climate change, emphasizing the necessity of being cautious about fake news, and was also an attractive piece of material with important information on the theme.

There were also some awareness-raising actions that people need to take to take care of the environment.

Throughout the prototyping process, the groups had the opportunity to apply the knowledge acquired in previous steps, consolidating their learning and developing essential skills for solving complex problems. The students had to work in groups, divide tasks, and organize the construction stages. The final product of this step was to manage the implementation ideas and present them orally to the large group present in the room, expecting to hear feedback on the proposals presented in Steps 5 and 6.

In Implementation and Evolution, students followed the implementation plan and responded to the following prompts, indicating their actions: Why will it be done? How will it be done? When will it be done? Who will do it?

Group 1 affirmed that it must be done to improve the quality of life at the school, not only for students, but also for teachers and school workers in general. It has to be done and organized by the school, since it involves a major renovation. It can be done as quickly as possible, with good planning and resource organization.

Group 2 highlighted that the game was developed to improve students' understanding, so it should be applied in the classroom to improve learning. It can be applied in the classroom during regular classes, in optional classes, or at other times at school. The game can be played at any time, but the teacher must be willing and prepared to use it. Since the game is ready, teachers only need to organize themselves to apply it in class.

Group 3 reported that paving in rural areas should be improved to help residents. They created a mockup to illustrate what could be fixed. It could be completed in a few months, depending on the funding available for the project. The municipal administration must be responsible for this through the Departments of Public Works and Environment and Infrastructure.

Group 4 pointed out that their prototype (folder) must be made to inform students, particularly those without access to information, and to

combat fake news on the topic. They can distribute the flyers from classroom to classroom or place them on the school bulletin boards during recess; it can also be distributed on the streets throughout the community. It can be done at any time, as long as it is planned. Students, along with teachers, can distribute the materials and give a brief explanation.

The Evolution involved feedback from the teachers and the entire class. After presenting their work, each group had time to listen to questions, praise, and suggestions. There was also a discussion about the implementation plan, which was the most frequent doubt among the designers when they shared their ideas. It was an essential moment for all groups, as the students were able to broaden their ability to move from the abstract to the concrete, as proposed by IDEO (2014), a possibility that the construction of an implementation plan can develop. They were also able to clarify how they developed the prototypes and further justify their choices. The students were excited about the idea being put into practice and demonstrated openness to feedback.

Conclusion

The issue of climate change is emerging due to the substantial changes on the planet, and combining these issues with active methodologies is of paramount importance for building knowledge. In this sense, the Design Thinking methodology proved to be a valuable support point as a teaching and learning strategy, providing a means to work on environmental issues, as in the case of this research, which focused on climate change and the development of personal and interpersonal skills essential to understanding the topic.

Throughout the meetings, it was observed that the skills proposed in this study emerged and strengthened (such as empathy, engagement, group work, creativity, collaboration, and communication). It was possible to see how these skills are linked to the DT steps and how they are developed

naturally and in a fun way among the Designs involved in the process. It is essential to highlight that DT in the teaching and learning process is not limited to the development of products or services, but to the formation of more critical, creative citizens engaged with the issue of climate change.

Furthermore, the results indicate that Design Thinking has the potential to transform pedagogical practice, allowing the students to be protagonists of their own learning. By involving students in challenging and collaborative projects, this methodology contributes to the development of more critical and creative citizens engaged with social and environmental issues. The flexibility of DT enables its adaptation to various contexts and content, making it a valuable methodology for building interdisciplinary projects and solving real problems.

Finally, the results os this study point to the potential of DT as a teaching and learning strategy to transform pedagogical practice and promote more meaningful and relevant learning for students. When articulated with complex themes, such as climate change, the study demonstrated that it can facilitate the teacher-student relationship. Although methodologically laborious, it has potential for the teaching and learning process, as it enables the critical development of students and the skills necessary to live in society.

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