Article

LINHAS CRÍTICAS

Insights on Design Thinking in the discussion of solutions for flooding

Percepções sobre o *Design Thinking* na discussão de soluções para alagamentos

Percepciones sobre el *Design Thinking* en el debate sobre soluciones para las inundaciones

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Highlights

Design Thinking as a teaching and learning strategy for understanding and combating environmental problems.

High school students propose solutions to combat flooding through Design Thinking.

The article highlights the contribution of Design Thinking to student protagonism.

Abstract

Design Thinking is an active, student-centered methodology that promotes the development of personal and interpersonal skills, such as motivation, collaboration, and communication. Thus, this article aimed to investigate third-year (Senior) high school students' perceptions of the application of Design Thinking to address flooding problems in Pernambuco. To this end, a qualitative-descriptive research study was conducted, using a case study in three steps: Application in the classroom; Application of the evaluation questionnaire on the methodology; Analysis of students' perceptions of Design Thinking. The results indicate that, for students, the use of Design Thinking proved important, providing opportunities for teacher-student engagement and positioning students as the main agents of their own learning. It can be concluded that students perceive Design Thinking as a methodology that stimulates creativity, empathy, and collaboration, elements that are part of active learning.

Resumo | Resumen

Keywords

Design Thinking. Chemistry teaching. High school students. Methodologies.

Received: 07/02/2025
Accepted: 02/25/2026
Published: 04/01/2026
DOI: https://doi.org/10.26512/lc32202658828

Introduction

Chemistry teaching has been criticized for maintaining pedagogical practices considered traditional, based on banking education, in which students are seen as mere "recipients" of information. As a result of changes that have permeated society over the years, the need for education viewed from other perspectives has grown, with various studies seeking to place students at the center of the learning process. According to Basílio and Ribeiro (2021), teaching requires fundamental assumptions, from the perspective of Paulo Freire's work, such as the recognition that human beings are unfinished, conditioned, and that education is a lifelong process. Therefore, viewing the teaching and learning process in only one way, through a single teaching methodology, limits the process of knowledge construction.

Traditional pedagogy has well-defined characteristics, such as students being considered a tabula rasa (blank slate), the teacher being the holder of all knowledge, the classroom not allowing for interaction, and being designed to meet the needs of teachers (Leite, 2018). Thus, students are not placed at the center of the teaching and learning process, hindering the promotion of meaningful, critical, and creative learning, which is necessary to educate citizens who are aware of their role in society. In this sense, thinking about methodologies that contribute to greater student involvement is proving to be very important. Current active methodologies can contribute in this regard, as they are known for making the teaching and learning process meaningful for students and teachers, where students are at the center of the learning process, teachers become mediators or facilitators of this process, and teaching becomes meaningful for both (Diesel *et al*., 2017; Leite, 2018; Versuti *et al.*, 2021).

In addition to concerns about educational issues, society faces major challenges, such as the negative impacts of environmental degradation, depletion of natural resources, droughts, soil degradation, freshwater scarcity, and loss of biodiversity. Regarding human-caused environmental degradation, it can be observed that other areas are also affected, impacting quality of life, education, ways of acting and thinking, the economy, politics, among others. Concerned about this situation, the United Nations proposed the Sustainable Development Goals (SDGs) with the aim of ending poverty, protecting the environment and climate, and ensuring global peace and prosperity (United Nations, 2015). The goals were implemented in the 2030 Agenda, in which 17 SDGs must be achieved by the year 2030.

Among the 17 Goals, some are intertwined with problems that are also observed in the school context, or that the education of citizens (in the school environment) can contribute to a more sustainable world. In this sense, Sasseron and Machado (2023) argue that school is a strategic environment for scientific literacy, enabling the education of individuals capable of critically understanding socio-environmental issues and acting in favor of sustainability. For example, Goal (Quality Education) points to the need to ensure access to inclusive, quality education, promoting equal

learning opportunities for all. To do justice to the fourth SDG, according to Rosa, Ghiggi, and Mota (2021), some methods have stood out in the academic community for favoring the training of professionals with a generalist, humanistic, critical, and reflective profile, which are difficult to develop in traditional teaching models, in which students take a passive stance during lectures. One of the methods that has been gaining prominence is active methodologies (Leite, 2021; Moran, 2015). Within the universe of existing active methodologies, Design *Thinking* (DT) stands out as a classroom methodology that can contribute to the development of personal and interpersonal skills.

In this sense, this study, which is part of a larger research project, sought to answer the question: Based on students' perceptions, is DT an effective methodology for promoting chemistry teaching in an engaging, creative, and empathetic way? To this end, high school students' perceptions of the DT strategy applied in chemistry classes focused on environmental education were investigated, with the aim of reducing flood-related damage in Moreno, a municipality in Pernambuco. It should be noted that case studies involving environmental issues, especially those using teaching methodologies such as DT, are still in their infancy in chemistry teaching.

Design Thinking

Active methodologies are gaining prominence in classrooms due to the need to adapt to education, caused by social changes. Bacich and Moran (2018) argue that, although transmission learning is important, an approach based on questioning and experimentation is more relevant for a comprehensive and deep understanding. According to Leite (2022), there are several active methodologies that can be used in the educational context, one of which is Design *Thinking.*

DT is a methodology based on challenges, stages, and organization, which also develops interpersonal skills. It is a process that involves a way of thinking, methods, and strategies (Cavalcanti & Filatro, 2016). DT can be applied in three ways: as an approach to innovation, a methodology for problem-solving, and a teaching and learning process (Nascimento & Leite, 2021; Silva Neto & Leite, 2023).

In education, DT generally involves four or five stages in the teaching and learning process. Although the names of the stages may vary depending on the author, each stage is specific and well-defined. In the literature review conducted by Nascimento and Leite (2021), it is observed that the studies investigated use five stages in DT, namely: Discovery, Interpretation, Ideation, Experimentation, and Evolution (Figure 1).

Figure 1
Stages of Design Thinking

Source: Adapted from Ideo (2013) and Cavalcanti and Filatro (2016).

In the first stage of the process (Discovery), defining the strategic challenge is fundamental and serves as a starting point for all other stages (Ideo, 2013; Nascimento & Leite, 2021). It is important to define the challenge and then narrow it down with questions about how to approach it. The choice of challenge should consider characteristics such as timeliness, relevance to students' lives, the ability to be approached in a humanized manner, and a combination of breadth and specificity. At this point, students are introduced to the challenge's context and encouraged to reflect on what they already know about it. In addition, it is useful to organize prior knowledge and plan exploratory research on a specific topic.

Interpretation, also called Immersion, is the second stage of DT. In Interpretation, students and teachers are introduced to people/facts that are related to the challenge. At this stage, students can develop empathy skills while immersed in the challenge (Silva Neto & Leite, 2020). This data is obtained through the data collection strategy. For Calvalcanti and Filatro (2016), data collection can be done in several ways to better understand the strategic challenge. After collecting and interpreting the data, students gather to discuss and create an empathy map. The empathy map "is a DT tool considered to be the most important, as it is used in the initial stages of the process, when the characteristics of the target audience are identified" (Silva & Gomes, 2020, p. 6). When using the empathy map, four keywords are considered fundamental: what the user "says," "thinks," "does," and "hears" in relation to the strategic challenge (Figure 2).

Figure 2
Empathy map

Source: the authors.

The third stage, Ideation, is where various ideas for solving the strategic challenge are formulated. According to Nascimento and Leite (2021), ideation occurs in two stages (brainstorming and refinement of ideas). On the empathy map, students are guided to the brainstorming stage. In Ideation, Ideo (2013) proposes some rules to ensure that it is carried out efficiently and achieves its objectives: (1) avoid judgment; (2) encourage bold ideas; (3) build on the ideas of others; (4) stay focused on the topic; (5) pay attention to all ideas presented; (6) use good visualization; (7) prioritize quantity over quality; and (8) accept mistakes as part of the process. At this stage of DT, the teacher's mission is to promote a safe and open space for all ideas to be created and welcomed, as it is mainly at this stage that students can develop and build creativity. After this, students should (in groups) choose the best ideas to solve the problem proposed in stage 1 (Discovery). At this point, it is important to meet the fundamental criteria of DT, which are to choose the most practical and innovative idea.

In the fourth stage, related to Prototyping (or experimentation), students are instructed to create prototypes and test them, obtaining *feedback*. Students must carry out rapid prototyping, which aims to quickly prototype and test the ideas chosen in the previous stage. Prototyping can take place in different ways, such as through the creation of drawings, flowcharts, sketches, mind maps, theater, digital material, mock-ups, models, stories, advertisements, among others. At this stage, students experiment with their ideas and test their prototypes, either individually or in groups. The prototype is shared with the aim of obtaining *feedback* on its feasibility. Prototyping helps students understand the final product they will obtain, and *feedback* allows them to fix anything that did not work and/or improve the prototype.

Finally, the fifth stage (Evolution) consists of developing and refining the solution to the proposed problem. Students will observe the success rate, progress, effects, and evaluations, and will also be able to make advances in the project (Ideo, 2013; Nascimento & Leite, 2021). At this stage, several time-consuming tasks are carried

out, such as assessing project progress, identifying the resulting impacts, drawing up an implementation plan, engaging stakeholders in the strategic challenge, promoting the idea, establishing partnerships, and disseminating the accumulated experience. This stage focuses on the future of the selected ideas, covering their sustainability, continuous development, applicability, and practical feasibility.

DT contributes to quality education by helping students develop interpersonal skills such as empathy, collaboration, leadership, innovation, and creativity, making them protagonists in the process of knowledge construction. For teachers, DT improves teaching practices by encouraging innovative and motivating activities, promoting a meaningful teaching and learning process, and developing their own interpersonal skills.

Environmental education and chemistry teaching

Over the years, environmental education has proven to be essential to discussions involving care for a more sustainable world. Several factors have contributed to these discussions, such as increased pollution rates, excessive use of natural resources, and high levels of deforestation, among others. According to Fragoso and Coutinho (2025, p. 1), "environmental education [...] strengthens citizenship education and promotes the development of critical and socio-emotional skills essential for sustainability," acting in an interdisciplinary, social, and economic context. Environmental education needs to act not only in the field of natural sciences, but also within an interdisciplinary context and in the economic and social fields (Dal-Farra & Valduga, 2012). For Nunes and Banhal (2022), school becomes the starting point for discussions involving environmental issues, which are addressed in an interdisciplinary manner. In this sense, chemistry can be one of the subjects present in different debates involving the environment, enabling the formation of critical citizens who are sensitive to environmental issues. In this way, the discipline of chemistry can contribute positively to sustainability, demonstrating how fundamental it is to addressing environmental and social challenges.

According to Souza *et al.* (2015), the interconnection between Environmental Education and Chemistry teaching allows students to observe environmental changes, which, in turn, improves their understanding of the curriculum content. The teacher's role is to develop a methodology that promotes reflection and critical understanding of reality. Furthermore, it is important to change how we think about chemistry teaching, which can and should contribute to a new vision of global sustainable development based on discussions in environmental education.

Environmental education is crucial for understanding and addressing problems such as flooding and landslides, which are common during the winter months in Brazilian cities. According to Brasil (1999), environmental education is understood as "the processes through which individuals and communities build social values, knowledge, skills, attitudes, and competencies focused on environmental conservation," reinforcing its role in building a society committed to preserving the planet. Chemistry, therefore, plays an important role in solving these environmental

challenges, but it is essential to engage society and develop skills to deal with these issues effectively.

In addition to concerns about teaching environmental education in chemistry classes, it is important to highlight the Sustainable Development Goals (SDGs) proposed by the United Nations in December 2015. The SDGs "are a global call to action to end poverty, protect the environment and climate, and ensure that people everywhere can enjoy peace and prosperity" (United Nations, 2015, n/p). They were proposed to fill a gap left by the Millennium Development Goals (MDGs), which were eight targets to be achieved by 2015. As these goals (MDGs) were not achieved, the 2030 Agenda was launched with new goals to be achieved by 2030. The SDGs present 17 goals (Figure 3) with 169 targets, so that nations can achieve them by the year 2030.

Figure 3
17 Sustainable Development Goals.

Source: United Nations Brazil (2015).

These goals and targets set out an ambitious and transformative vision, seeking nations committed, for example, to the human right to drinking water, sanitation, sufficient food, and universal access to affordable, reliable, and sustainable energy, among others. In this context, enabling the discussions present in the SDGs, this research allows students to develop skills and competencies through goals 4, 6, 9, and 11.

These objectives were present throughout the DT methodology application process. Therefore, this research presents possibilities for education focused on active student participation, aiming at sustainable development and the construction of innovative teaching.

Methodology

To investigate students' perceptions regarding the application of DT to the problems caused by flooding in the state of Pernambuco, this research is qualitative and descriptive in nature, mediated by a case study. It is agreed that research of this nature aims to answer very specific questions based on a level of reality that cannot be quantified (Minayo, 2001) and that when it permeates a case study, it is characterized by an understanding of the description and interpretation of the facts explored without any concern for mathematical or statistical variables. Regarding the case study, Yin (2015) emphasizes that its objective is to analyze and record facts for later interpretation. In this research, the focus is on the floods that occurred in the state.

For the application of the DT methodology as a teaching and learning strategy, two third-year (Senior) high school classes were selected from a public school in Moreno, a municipality in the state of Pernambuco. The selection of classes was based on their proximity to the topics of environmental and sustainable chemistry, which are covered in the third-year (Senior) high school curriculum, to comply with the guidelines established by the National Common Curriculum Base (BNCC) (Brazil, 2018) and the High School Chemistry Curriculum Parameters (Pernambuco, 2013), and because the students had experienced the floods that occurred in Moreno/PE. The third-year (Senior) class A had 44 students, and the third-year (Senior) class B had 34 students, totaling 78 students, of whom 47 students submitted the voluntary participation form for the study.

In cases where students were minors, the consent form was signed by their parents or legal guardians. For students of legal age, the document was signed by the participants themselves, in accordance with the ethical guidelines established by the National Health Council Resolution (CNS, 466/2012), which regulates research involving humans in Brazil.

To avoid confusion between the methodological stages of the research and the stages of the DT, this text uses the term "steps" to refer to the research stages. Thus, the planning and organization process for this study consisted of three steps to achieve the objective of this research: Step 1 – Application of DT in the classroom; Step 2 – Application of the evaluation questionnaire on the methodology presented; Step 3 – Analysis of students' perceptions related to the use of DT.

It should be noted that, during the practical application of DT in this study, DT was used as a teaching and learning strategy. In this sense, the lesson plan was developed based on the proposal by Cavalcanti and Filatro (2016) and the guidelines by Ideo (2013), which outline five main stages of DT: Discovery, Immersion, Ideation, Prototyping, and Evolution. The lesson plan was structured in three steps, as detailed below.

The DT was applied in the research during three three-hour sessions, in which all stages took place in the school auditorium with both classes (Chart 1).

Chart 1
Didactic sequence of lessons and DT stages in the lesson plan.

Class	DT stage	Student action(s)	Duration
1st class	Discovery	Discovery of the problem by students.	3 hours
	Immersion	Guidance for empathetic interviewing. Group formation.	
2nd class	Immersion	Debates between groups. Preparation of the empathy map. Review of chemical concepts.	3 hours
3rd class	Ideation	Developing ideas for solving the problem. Discussion of ideas among groups.	3 hours
	Prototyping	Selection of the best ideas presented by each group. Rapid prototyping.	

Source: the authors.

In the first class, Discovery, the challenge proposed to the students was presented in order to familiarize them with the topic. The challenge suggested was: Considering the guidelines for sustainable development, how can we reduce the damage caused by the floods that occurred in May 2022 in the municipality of Moreno, Pernambuco? To provide students with additional information, in addition to teacher-student and student-student discussions about the challenge, news reports about the floods were used, as well as videos and images that recalled the events that took place in the city. During the debates, a questionnaire was administered to assess the students' prior knowledge of the subject matter. Finally, in the first class, a presentation and guidance session was held on the procedures for the empathetic interview that the students would conduct and submit as an assignment in the second class. The empathetic interview was proposed with the aim of provoking reflection among students (empathic vision) regarding the emotions and thoughts of people who were directly or indirectly involved in the strategic challenge.

In the second class, considered the Immersion stage, a roundtable discussion was held about the interviews the students conducted with people who suffered from the floods, in addition to the construction of the empathy map. Furthermore, in the second class, the teacher presented a lecture/dialogue involving chemical concepts related to the topic, linking the content to possible causes of flooding, the role of environmental chemistry, and chemical and physical transformations, issues involving the cycle of materials in the environment, among others.

Finally, in the third class, two stages of DT took place: ideation and prototyping. At first, the students were invited to work in groups to think about strategies to alleviate, reverse, and improve the situation of the city and the people who suffered from the flooding. In general, students were encouraged to think of solutions to the proposed challenge, the goal of which was for students to be creative, develop teamwork skills, and think critically about the topic. In the second instance, the

students working in teams had to select the best ideas (based on consensus within the groups) and choose one to present to the whole group.

In the second step, an online form was developed to analyze students' perceptions of the application of the teaching strategy (step 1). The questionnaire presented in Chart 2 was created in Google Forms and sent to students via the *WhatsApp*® group of the two classes participating in the survey.

Chart 2
Questionnaire on the development of the research.

1) In light of what we did in class, what does chemistry have to do with sustainable development? Give examples.
2) How important is it to study sustainability?
3) What did you think of the classes on chemistry and sustainability? ( ) Not good ( ) Average ( ) Good ( ) Great
4) Do you think you learned better this way? ( ) Yes ( ) No
5) On a scale of 0 to 10, how would you rate this methodology? Where zero is the minimum score, and 10 is the maximum score
6) What positive and/or negative points did you observe in the three meetings?
7) From 1 to 4, did you understand the subject well during class? 1. I did not understand anything 2. I only understood part of it. 3. I understood well. 4. I understood the lessons very well.
8) What did you think of the first and second stages of the methodology used, discovery and immersion? (in which interviews and debates on events related to the topic took place).
9) What did you think of the empathy map?
10) What did you think of Ideation (*Brainstorming*)? (The third stage of our research, where you came up with several ideas to solve our problem).
11) Tell us, overall, what you thought of DT-based classes. Do you think the school can invest in teaching methods like this?
12) Check the one you most identify with: ( ) The teacher did not conduct the class well, and I did not like the methodology used. ( ) The teacher did not conduct the class well, but I liked the methodology used. ( ) The teacher conducted the class well, but I did not like the methodology used. ( ) The teacher conducted the class well, and I liked the methodology used.
13) Given the classes presented, which do you prefer? ( ) Traditional classes, held in the classroom and without much student participation. ( ) Classes with active methodologies and full student participation.
14) Did you feel that you learned about the subject covered? ( ) Yes ( ) No.

Source: the authors.

At the end of the entire application, a summary was made of all the data obtained during the process and organized into charts, tables, and texts to better describe the contributions of DT in the teaching and learning process.

The data were processed using the interpretative analysis proposed by Zanela (2009). In this analysis, the researcher discusses the research data and takes a position on the respondents' ideas. To this end, the data *corpus* was collected from responses to a questionnaire available on Google Forms and analyzed in its entirety. Nevertheless, for the presentation of the results in this study, only a few excerpts will be presented, chosen for their ability to illustrate the meanings

constructed from the set of data analyzed (Zanela, 2009). The procedure consisted of five steps: 1) Accessing and organizing the responses obtained through Google Forms; 2) Successive readings of all responses to the 14 questions in the questionnaire; 3) Exploration of the material, seeking to understand the meanings attributed by students to their experiences in the classroom, considering the theoretical assumptions of DT and active methodologies; 4) Organization of responses by representativeness, selecting excerpts that illustrate examples of the phenomenon studied; 5) Interpretative record, allowing for analytical inference.

Thus, the interpretation of the data was based on the dialogue between the participants' discourses and the theoretical framework adopted, according to Zanella's (2009) perspective, in which the researcher takes an interpretative and critical stance towards the ideas expressed in the texts. Furthermore, according to Severino (2007), interpreting a text implies taking a position on the ideas presented, going beyond the explicit message by reading between the lines, establishing a critical dialogue, and exploring the richness of the ideas presented, relating them to other theoretical perspectives.

At this point, it is worth noting that during the transcription of the texts produced by the students in the questionnaire, care was taken to preserve the accuracy of the responses so as not to alter the original version, keeping the writings exactly as they were submitted by the students. To preserve anonymity, student responses, data, or information transcribed in the results were indicated by the word "Student" followed by an Arabic numeral from 1, 2, 3, [...], up to 36, for example, "Student 1," "Student 2," [...], "Student 36."

Results and discussion

After implementing the teaching strategy, the second step of this research began, which consisted of sending an online questionnaire about the activity carried out. The questionnaire (Chart 2) was created using Google Forms and distributed to students through a *WhatsApp*® group they were part of. Of the 78 students enrolled in the two classes (44 in 3rd year A and 34 in 3rd year B), 36 responded to the questionnaire, with 20 responses from 3rd year A and 16 from 3rd year B. Furthermore, it is considered that the responses obtained were sufficient and met the number required for data collection and subsequent research conclusions.

When asked about what chemistry has to do with sustainable development? (question 1), Only three students gave vague answers, as they did not provide examples, limiting themselves to responding as follows: "Many things" (Student 1) and "Everything" (Student 23; Student 36). Other students pointed out the connection between chemistry and sustainable development more precisely. Some excerpts from their statements were: "Advances in the production of biofuels, alcohol, and biodiesel are processes that are entirely in line with environmental preservation, as they come from renewable sources" (Student 14) and "Using chemistry in a way that does not harm the environment, recycling, etc." (Student 25). The students' responses indicate that there was possibly an understanding of the importance of chemistry in sustainable development and what actions it can

take, strengthening the role of education as an indispensable tool for achieving sustainable development. In this regard, Amorim (2021, p. 9) highlights that "Chemistry in the face of reality has much to contribute to humanity's achievement of sustainability."

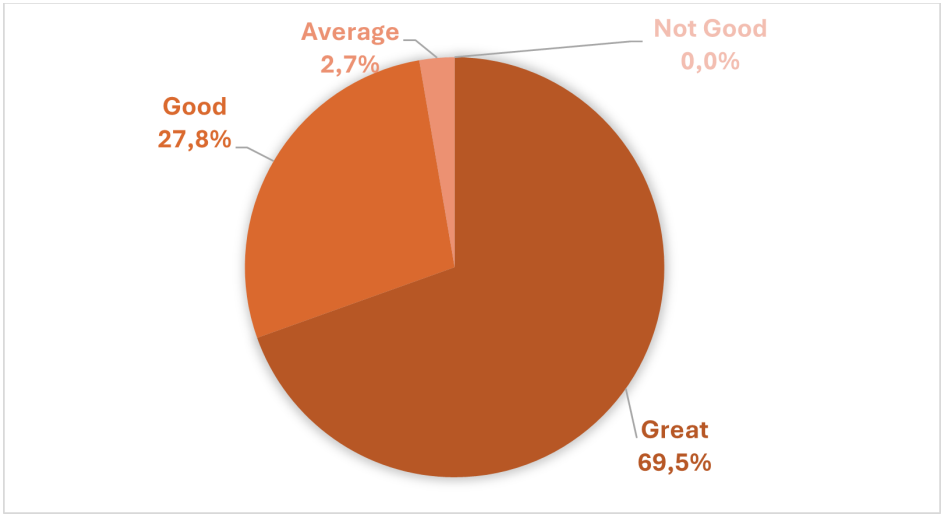
Regarding the responses obtained from question 2 (How important is it to study sustainability?), the student stated that:

> In addition to improving the economy, since clean resources, especially energy production, can reduce costs for our generation, sustainable sources also preserve the environment and prevent major natural disasters (Student 5).

In this statement, it can be inferred that the student understands the impacts of sustainability on the economy. Other responses given by students were "To have a better understanding of what is and is not sustainable so as not to harm the planet" (Student 7), "Our lives are rooted in the environment, so studying sustainability means learning how to preserve the environment in which we live" (Student 8). Furthermore, the question made it possible to infer how important students thought it was to study sustainable development and how much they felt they were included in this sustainability process, when they used words in their answers that included them in this process.

Starting with the third question in the questionnaire, the questions focused on students' perceptions of the three classes (questions 3-7). Thus, when asked what they thought of the classes on chemistry and sustainability (question 3), the students gave their opinions (Chart 1).

Chart 1
Students' responses on what they thought of the classes on chemistry and sustainability



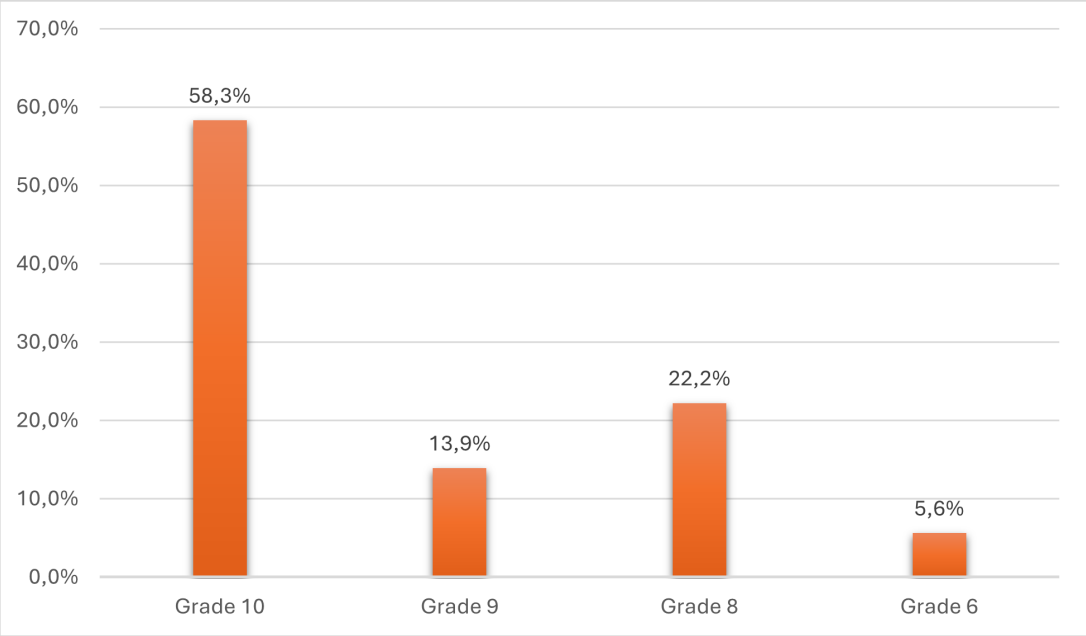
Source: the authors.

Regarding the question of whether students learned better through the methodology applied (Do you think you learned better this way? – Question 4), all students answered "Yes," indicating that, in the context of these students, the DT proposal can be considered an appropriate strategy for chemistry teaching. It

should be noted that DT is not the definitive solution for chemistry classes. Still, its approach enables teachers and students to move away from the traditional model of expository, non-interactive instruction (Leite, 2022).

Still on the general perception of the class, when asked to rate the activity (On a scale of 0 to 10, how would you rate this methodology? Where zero is the minimum score, and 10 is the maximum score – question 5), 58.3% gave the proposal the maximum score, followed by 22.2% who gave it a score of 8, and 13.9% who gave it a score of 9. The lowest grade given by students was 6, representing 5.6% (Chart 2).

Chart 2
Student responses regarding the methodology applied in class



Source: the authors.

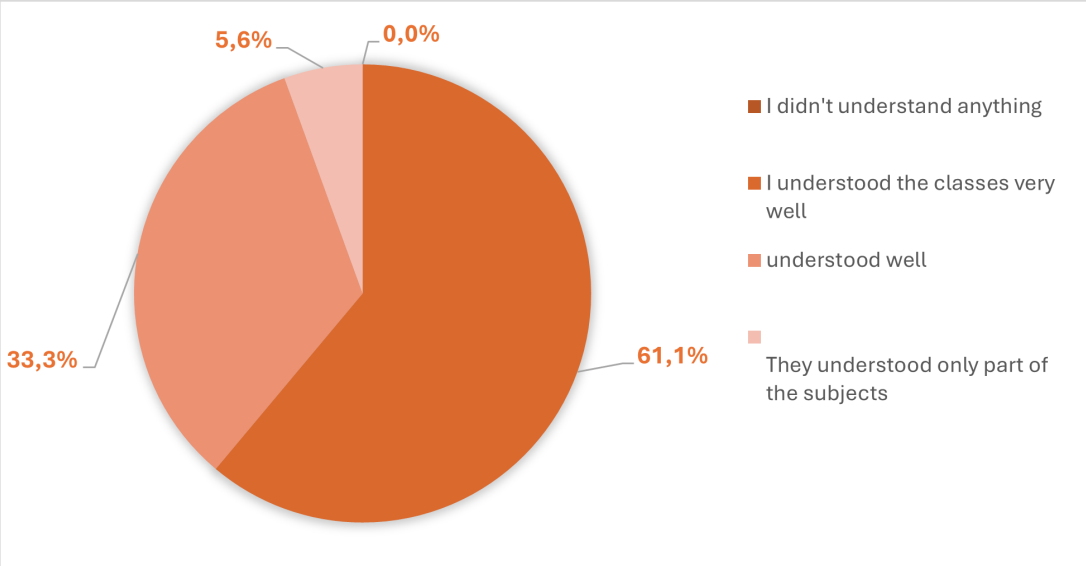
The answers to questions 3 to 5 of the evaluation questionnaire show that students had a favorable attitude toward the methodology applied. The DT approach can be a relevant strategy for improving teaching and learning, as it directly involves students in the process and places them at the center of learning, a characteristic of active methodologies (Leite, 2018).

Regarding the answers to question 6, the students presented negative points; many answers were similar to that of the student who said: "There were no negative points" (Student 9). Regarding the positive aspects, some responses stand out: "The teaching style is more interactive" (Student 10) and "Super dynamic methodology, wide-ranging conversations, but in a gentle way, always listening to what everyone has to say" (Student 31). The students considered the methodology to be dynamic and interactive, highlighting contributions from active methodologies, such as reflective and participatory involvement, where they experiment and create with the teacher's mediation. They also emphasized the importance of listening and being heard, highlighting the value of the empathy map and the DT immersion

stage, where everyone participated and gave their opinions. Those answers help the teacher understand how students evaluated classes based on active methodologies, such as DT. The positive points indicate that, when applied correctly, the methodology can benefit the teaching and learning process.

When asked if they understood the subject during class (question 7), 61.1% of students responded that they understood the lessons very well. Meanwhile, 33.3% stated that they were able to understand the lessons well, and 5.6% stated that they only understood part of the subject matter. No one in the class selected the option "I did not understand anything" (Chart 3).

Chart 3
Level of understanding of the content covered in class



Source: the authors.

Based on the responses in Chart 3, it can be inferred that 94.4% of participants indicated that they were able to learn the content through the application of DT as a teaching and learning strategy. Furthermore, given that no student indicated they did not understand, it is believed that the inclusion of DT enabled students to understand the subject to a greater or lesser degree. Although the results of this teaching strategy can only be validated after a certain period of time (to verify whether effective learning has taken place), it was significant to identify students' perceptions of what they believe they have understood, allowing them to evaluate the effectiveness of the proposal in relation to how they learn.

Regarding the evaluation of the DT stages, the students shared their perceptions. When asked about their opinions on the first two stages of the DT (Question 8), some students responded: "Great, we were able to see things from the perspective of people whose homes were flooded" (Student 7); "I found it very interesting, because this methodology gave us more knowledge about our city" (Student 12). The responses highlight the importance of teachers, when applying the design, raising questions, challenges, and problems that are relevant to students' daily lives, thus facilitating the teaching and learning process. Regarding the stages of

DT, Leite (2022) emphasizes the need for the Discovery phase to be based on a topic familiar to the student, so that they are actively involved in the search for solutions to the challenge presented.

Regarding what students thought about the empathy map (Question 9), some of the responses obtained were: "[it was a] moment of reflection, where we see people's pain expressed in words" (Student 2), "A very different way to stimulate our thinking and make us reflect and learn" (Student 13), "I liked it because it led us to put ourselves in the shoes of people who suffered from the floods and try to do something to help" (Student 14). The answers to this question indicate that the objectives presented in the application of the empathy map proved to be appropriate, as it enabled students to develop empathy, to reflect on the feelings of others, thus motivating them to think about how they could solve the problems that affected those people. In this context, Cavalcanti and Filatro (2016, p. 169) highlight that the empathy map "helps to see the problem from the other person's perspective and, thus, imagine what they think and feel."

When asked about the third stage of DT, Ideation (Question 10), 94.4% of students said it was interesting and challenging. 6% of students consider the proposal good, but did not like it very much. No student responded that they thought the proposal was not meaningful to them. One of the roles that teachers play in active methodologies is to encourage students to think and think critically (Diesel *et al*., 2017). For Omachi *et al.* (2025), the teacher's role in active methodologies is to serve as a mediator, guiding students to think critically about problems, formulate hypotheses, and build collaborative solutions. In this sense, the Ideation stage is a possibility to be addressed in the classroom, assisting the teacher and encouraging students to think, in which group dynamics favor the "creation and categorization of ideas aimed at solving a problem or conceiving something new" (Cavalcanti & Filatro, 2016, p. 179).

When asked to give their opinion on what they thought of the classes that were covered through DT (question 11), the students responded that "The school could and should invest. It was cool to have something different from what we have every day" (Student 13), "Yes, it is something different that distracts us a little from the traditional form of classes, where we just listen to the teacher" (Student 15), "Yes, I think schools should apply methodology like the one used by the teacher" (Student 28). The students' answers indicate that the use of methodologies such as DT can be an alternative to traditional classes, which generally do not involve student participation in knowledge construction. By adopting active methodologies in the classroom and moving away from traditional teaching approaches, teachers can promote more active and meaningful learning for students (Cavalcanti & Filatro, 2016; Leite, 2022). In this context, the DT approach emerges as a strategy that enables and promotes innovation in the field of education, establishing itself as a relevant and appropriate tool for contemporary educational challenges.

Furthermore, through projects involving school subjects (chemistry, physics, biology, history, etc.) and sustainability, schools can connect with society and apply the knowledge acquired for the benefit of the local community. During the DT,

students conducted local environmental impact studies, in which the empathy map and brainstorming contributed significantly to the proposal of solutions, proving to be a positive force for social transformation.

When asked about the teacher's conduct of the class (question 12), all students marked the option that said, "The teacher conducted the class well, and I liked the methodology used." These answers underscore the importance of teacher preparation in applying methodologies, planning, evaluating, and identifying the goals they aim to achieve in their teaching practice, considering the significance of these actions for teachers. According to Bacich and Moran (2018, p. 42), "The role of the teacher involves planning meaningful learning experiences that mobilize different skills, promoting autonomy, critical thinking, and the ability of students to act in diverse contexts."

Regarding the responses obtained for question 13 (Given the classes presented, which do you prefer?), 97.2% of students chose the option that they prefer "classes with active methodologies and full student participation," while only 2.8% of students chose the alternative of having "traditional classes, in the classroom and without much student participation." According to Diesel *et al.* (2017), active methodologies enable students to participate more actively in the teaching process, behaving autonomously, involving problematization of reality and reflection, thus distancing themselves from teaching based on "storing information" to teaching that promotes engagement, inviting them to reflect on problems that make sense to them.

Finally, the last question in the questionnaire asked students to think about how they felt about their learning (question 14). All students stated that they felt they had learned about the topic, although more time is needed to confirm that effective learning occurred. The students' responses indicate that, in their view, they had learned the covered content, demonstrating their "ability to make decisions about their learning" (Leite, 2018, p. 590). On the other hand, the students' responses corroborate the conclusions of other studies, indicating that active methodologies can contribute to meaningful learning (Cavalcanti & Filatro, 2016). In these approaches, students gain autonomy, actively participate in the learning process, question and propose solutions to everyday challenges, and promote deeper and more lasting learning.

Conclusions

The research highlights elements that favorably corroborate the inclusion of Design *Thinking* as a teaching and learning strategy, based on an approach that proposes solutions to the floods that occurred in the municipality of Moreno/PE, in which the students are involved.

High school students' perceptions of the DT strategy applied in chemistry classes were mostly positive. Furthermore, the lessons covered in classes involving environmental chemistry and sustainability content contributed to an engaging, creative, and empathetic approach to chemistry teaching. The application of DT in

the classroom fostered an environment in which students could learn not only chemical concepts but also how these concepts relate to environmental issues, specifically flooding and its consequences.

Regarding the impact of DT on the knowledge-building of those involved, it was evident that DT proved to be a relevant pedagogical strategy, as its structured stages promote more dynamic and participatory classes, contributing to the teaching and learning process.

Regarding students' perceptions of the impact of DT on the construction of their knowledge, it was evident that the methodology was an effective strategy in the teaching and learning process, as it presented stages that supported a more engaging and active class for students, favoring the construction of knowledge.

In view of the above, the results of this research allow us to reflect on DT's contribution to student learning, highlighting how active methodologies can serve as allies in teaching practice. The application of DT offers students an active learning experience, allowing them to intervene in their reality in a creative, empathetic, and critical way. Although the use of DT stages facilitates the discussion of chemistry teaching content in an applicable manner, it is also important to explore the possibilities DT offers for developing interpersonal skills in both students and teachers. Such skills include empathy, teamwork, leadership, creativity, communication, flexibility, and critical thinking, all of which are essential for harmonious and effective coexistence in society.

Finally, it is important that future research explore the application of Design *Thinking* in chemistry teaching. DT can be an effective strategy for teachers, helping to show how chemistry can solve environmental problems and develop students who are critical, creative, and focused on problem-solving.

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Resumo

O *Design Thinking* se configura como uma metodologia ativa centrada no estudante, favorecendo o desenvolvimento de competências pessoais e interpessoais, tais como motivação, colaboração e comunicação. Dessa forma, este artigo teve como objetivo investigar as percepções dos estudantes do terceiro ano do ensino médio sobre a aplicação do *Design Thinking* na solução dos problemas dos alagamentos que aconteceram em Pernambuco. Para isso, realizou-se uma pesquisa de abordagem qualitativa-descritiva, mediada por um estudo de caso, em três passos: Aplicação em sala de aula; Aplicação do questionário avaliativo sobre a metodologia; Análise das percepções dos estudantes sobre o *Design Thinking*. Os resultados apontam que para os estudantes a utilização do *Design Thinking* se mostrou importante, oportunizando o envolvimento professor/estudante e tendo os estudantes como principal agente de sua aprendizagem. Conclui-se que os estudantes percebem o *Design Thinking* como uma metodologia que estimula a criatividade, empatia e colaboração, elementos que fazem parte da aprendizagem ativa.

Palavras-chave: *Design Thinking*. Ensino de química. Estudantes do ensino médio. Metodologias.

Resumen

El *Design Thinking* se configura como una metodología activa centrada en el estudiante, que favorece el desarrollo de competencias personales e interpersonales, tales como la motivación, la colaboración y la comunicación. De este modo, el objetivo de este artículo fue investigar las percepciones de los estudiantes de tercer año de secundaria sobre la aplicación del *Design Thinking* en la solución de los problemas de inundaciones que se produjeron en Pernambuco. Para ello, se llevó a cabo una investigación de enfoque cualitativo-descriptivo, mediada por un estudio de caso, en tres pasos: aplicación en el aula; aplicación del cuestionario de evaluación sobre la metodología; análisis de las percepciones de los estudiantes sobre el *Design Thinking*. Los resultados indican que, para los estudiantes, el uso del *Design Thinking* resultó importante, ya que propició la participación del profesor y los estudiantes y convirtió a estos últimos en los principales agentes de su aprendizaje. Se concluye que los estudiantes perciben el *Design Thinking* como una metodología que estimula la creatividad, la empatía y la colaboración, elementos que forman parte del aprendizaje activo.

Palabras clave: *Design Thinking*. Enseñanza de la química. Estudiantes de secundaria. Metodologías.

Linhas Críticas | Journal edited by the Faculty of Education at the University of Brasília, Brazil
e-ISSN: 1981-0431 | ISSN: 1516-4896
http://periodicos.unb.br/index.php/linhascriticas

Full reference (APA): Nascimento, R. M. F. do, & Leite, B. S. (2026). Insights on Design Thinking in the discussion of solutions for flooding. *Linhas Críticas*, *26*, e58828. https://doi.org/10.26512/lc32202658828

Full reference (ABNT): NASCIMENTO, R. M. F. DO; LEITE, B. S. Insights on Design Thinking in the discussion of solutions for flooding. **Linhas Críticas**, 26, e58828, 2026. DOI: https://doi.org/10.26512/lc32202658828

Alternative link: https://periodicos.unb.br/index.php/linhascriticas/article/view/58828