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Superheroes and education: chemistry that works!

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A B S T R A C T

Chemistry teaching in high school has been the subject of studies that seek diversified ways of teaching chemistry, making teaching dynamic, stimulating, collaborative, etc. With this in mind, this work aims to present the material produced in research by PIBIC/Uneal, where we redesigned the Periodic Table (PT) with each element represented by a superhero. A book was also produced with an illustrative story about the chemical elements, and both works were made available free of charge to all those involved and other interested parties. To this end, we shared the research in public schools in Arapiraca, in high school classes. Later, we applied an online questionnaire to the students to identify their opinions about the material that was being produced. As a result, we found that 76.3% of the students showed interest in using a more illustrative PT, with information from everyday life; 88.4% considered it interesting to establish a relationship between the content of the PT and superheroes; 91.1% of the students really liked the illustrative materials produced; 85.7% found the cards about the TP elements to be well-designed; 89.3% considered the information contained in the cards to be easy to understand, and 96.4% are interested in receiving the illustrative chemistry materials when they are finished.

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RESUMO

O ensino de química na educação básica tem sido objeto de estudos que busquem formas diversificadas de ensinar a química, deixando o ensino dinâmico, instigante, colaborativo etc. Pensando nisso, este trabalho tem como objetivo apresentar o material produzido em pesquisa do PIBIC/Uneal, onde repaginamos a Tabela Periódica (TP) representado cada elemento por um super-herói. Também foi confeccionado um livro com história ilustrativa sobre os elementos químicos, sendo as duas obras disponibilizadas gratuitamente para todos os envolvidos e demais interessados. Para isso, socializamos a pesquisa em escolas públicas de Arapiraca, em turmas de ensino médio. Posteriormente, aplicamos um questionário online para os alunos para identificarmos suas opiniões a respeito do material que estava sendo produzido. Como resultado verificamos que 76,3% dos alunos demonstraram interesse em utilizar uma TP mais ilustrativa, com informações do cotidiano; 88,4% consideraram interessante estabelecer uma relação entre o conteúdo da TP e super-heróis; 91,1% dos estudantes gostaram muito dos materiais ilustrativos produzidos; 85,7% acharam as cartas sobre os elementos da TP bem elaboradas; 89,3% consideraram as informações contidas nas cartas de fácil entendimento, e 96,4% têm interesse em receber os materiais ilustrativos de química quando finalizados sua confecção.

Keywords:
Super-heróis, Química, Ensino.

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Introduction

Over time, chemistry teachers and researchers of Chemistry Teaching have understood that classes need tools that seek to facilitate teaching work and student understanding of the content studied. Textbooks and similar materials, even in the face of all the technology that has emerged in recent decades, continue to be a source of research for teachers when preparing their classes, and a source of study for students (Borges et al., 2021; Oliveira, 2019; Pereira et al., 2020; Barros, 2021).

The use of diverse materials, in addition to textbooks, such as comics, e-books, booklets, among others, was recognized by the Lei de Diretrizes e Bases (LDB) and the Parâmetros Curriculares Nacionais (PCNs), because they are resources that encourage reading, allowing students to find less difficult to concentrate on texts intended for the study of chemistry (Silva, 2020; Passos; Vieira, 2014; Aquino et al., 2015).

As examples of relevant illustrative didactic books to learning chemistry, we can mention the illustrative dictionary of chemistry (Oxlad et al.; 2012), Chemistry in comics, (Criddle, 2013), Illustrated Chemistry, (Azulay, 2023), “In a galaxy not so far away... Chemistry, ludicity and comics” (Cruz, 2020) among others.

However, these and many other educational books are unfortunately not freely accessible. Therefore, this led to the problem of this work: Would high school students in public schools like to receive chemistry books about the Periodic Table (PT) with the chemical elements represented by superheroes? Therefore, we seek to produce, socialize and distribute free of charge the material produced on the chemical elements of the PT, representing each element by a superhero.

Methodology

The methodology of this work is characterized as mixed as for the approach (Ferreira, 2015; Günther, 2006), consisting of quantitative data (Lüdke; André, 1986; Bardin, 1979), with the application of questionnaires to high school students from public schools in a city in the State of Alagoas, and qualitative due to corroborating the data obtained with information from the literature (Gil, 2022).

This is a basic research, as for the purpose, aimed at expanding knowledge about the use of didactic materials in chemistry teaching, and exploratory in terms of its purpose, as it allows investigating in the literature the types of scientific research and their set of procedures to support logical reasoning about the object researched in here (Cesário, 2020).

In terms of method, it is a survey research (Gil, 2022) due to the request for students’ opinions on the use of illustrative didactic materials in chemistry classes, and bibliographical because it is based on renowned works to consolidate the data obtained (Praia; Cachapuz; Pérez, 2002). The research did not go through the ethics committee, since it falls under CNS Resolution No. 510, 2016, in its article 2, XIV. The methodology comprised four steps, as seen in table 1:

Table 1.

Steps of the methodology.

Step	Description
Application of the first questionnaire	At the beginning of the 2024 school year, after contacting the schools principal where the research was conducted and after sharing the project with the students, we applied the first questionnaire to students from six public high schools located in the city of Arapiraca, in the State of Alagoas. The target audience was classes in the 1st, 2nd and 3rd years of high school, in the regular daytime teaching modality. This initial questionnaire was important for students to suggest what they would like to see in the didactic materials that would be produced.
Preparation of illustrative teaching materials.	To create the didactic materials, the following softwares were used: Canva (2024), a free-access graphic design platform, used to create the cards for each chemical element, and the SeaArt software (2024), an Artificial Intelligence (AI) platform, also free-access, used to create the images of each superhero that would be used on the cards.
Application of the second questionnaire	When we finished creating the didactic materials, we held another meeting with the students at the schools so that they could see the finished material. We asked them to answer a second questionnaire so that we could find out what they thought of the material and if they had any suggestions for improving it.

Results and discussions

From this moment, we will analyze and discuss the results obtained, which will be analyzed in two steps: in the first step, we will analyze the data obtained for the first questionnaire applied to the students and, in the second step, we will analyze the data obtained for the second questionnaire applied to the students.

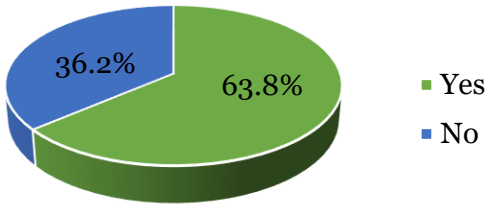
First step: analysis and discussion of data from the first questionnaire.

The first questionnaire, which contained 10 questions, was applied to students, and we received 224 responses. The questions were related to PT concepts, as well as questions about students' opinions on the use of illustrative materials to study chemistry, among others.

In the first question, we asked "In chemistry classes, have you ever had access to illustrative materials about the content of the Periodic Table?". For this question, we obtained the following data (graph 1):

Graph 1.

Data obtained for the first question of the first questionnaire.



We observed that 63.8% of students had already had access to illustrative materials on the Periodic Table and 36.2% of students had not yet had access to this type of material. These results show that more still needs to be done so that everyone has access to the most varied forms of reading about chemistry, encouraging scientific literacy.

For the second question, we asked "Would you like to receive illustrative chemistry materials for free?" For this question, we obtained the following data:

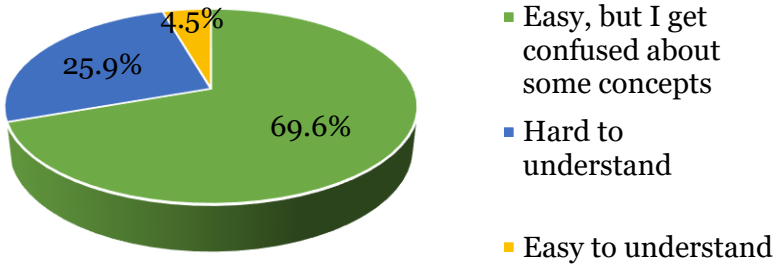
Options	Percentage (%)
Yes	96.9
No	3.1

It was observed that 96.9% of the students interviewed would like to receive free illustrative didactic chemistry materials, while 3.1% were not interested. This data motivated us to develop our research to provide students with illustrative didactic chemistry materials in contemporary language, encouraging them to read about PT.

The third question asked the following question: "When you studied/are studying the content on the periodic table, did you find?" For this question, we provided 3 answer alternatives, and we obtained the data verified in graph 2:

Graph 2.

Data obtained for the third question of the first questionnaire.



It is observed that 69.6% of students find the subject of PT easy, but they get confused about some concepts; 25.9% find it difficult and 4.5% consider it an easy-to-understand

subject. We can assume that most students need help to understand the content of PT. In the work of Dantas et al. (2016, p. 3) similar data were obtained where these authors found that 55% of students had difficulty understanding the content about PT.

In the fourth question, we asked "Would you like to study with a more illustrative periodic table and with information from everyday life?" The results for this question were:

Options	Percentage (%)
Yes	76.3
Whatever	21.9
No	1.8

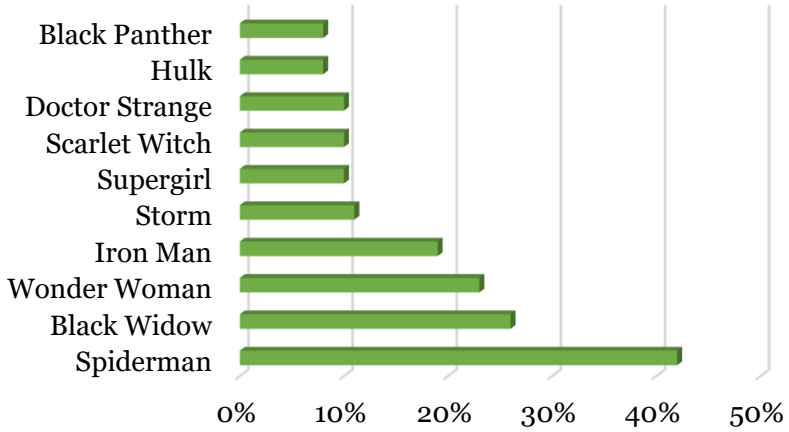
It is noted that 76.3% of students show interest in using a more illustrative PT with information from everyday life, while 21.9% have a neutral position and 1.8% show no interest in using it. These illustrative materials, as demonstrated by Leite (2020, p. 86), because they are an unusual material in the classroom, end up arousing students' curiosity and motivation to carry out activities, allowing the development of cognitive skills, such as thinking and imagining.

Given that the objective of our research was to develop illustrative didactic materials that combine PT content with superheroes, we inform that questions seven, eight and nine refer to this relationship between PT and superheroes.

Thus, in the seventh question, the question was asked "Which of these superheroes do you most identify with (style, personality, attitude, etc.)?". For this question we obtained the data contained in graph 3. We clarify that the sum of the percentages exceeds the value of 100%, because students could mark more than one option.

Graph 3.

Data obtained for the seventh question of the first questionnaire.



The data reveal the characters with which students identify most, with Spider-Man being the most cited (42%), followed by Black Widow (26%) and Wonder Woman (23%). Ornellas and Mello (2020, p. 556), in a similar study, showed that the use of superheroes in

the study of chemistry is a relevant initiative, since students demonstrated greater interest and participation in class.

In the eighth question, we sought to assess whether students would find the study of PT more attractive if each element was represented by a superhero. Thus, we asked the following question: “Do you think it would be interesting to relate the contents of the Periodic Table to superheroes?” The results of this question were as follows:

Optios	**Percentage (%)**
Yes	88.4
No	11.6

It is observed that 88.4% of students consider it interesting to establish a relationship between the content of the PT and superheroes, while 11.6% do not find it interesting. Pinto and Soares (2022, p. 33) and Ramires (2022, p. 16) showed the acceptance of this type of approach in chemistry classes by mentioning that works with a vision ludic and activities as opposed to passivity tends to attract teenagers to the necessary engagement in a didactic activity.

The ninth question was designed as a confirmation of question eight, and thus, we sought to know “If each chemical element in the periodic table was a superhero, would it be easier to understand the content?” And for this question we got the following answers:

Options	**Percentage (%)**
Yes	68.8
Whatever	22.3
No	8.9

We noted that 68.8% of the students responded that it would be easier to understand the PT content if each element was represented by a superhero, while 22.3% chose “Whatever” and only 8.9% marked “No”. These results reflect the students’ interest in studying the PT content using didactic materials that address the content with superheroes.

Question 10 was open-ended, allowing students to offer suggestions (Table 1) for the illustrative materials that would be created, providing valuable insights from the students and contributing to a material that is more aligned with their expectations and interests. The students are represented from A1 to A7, and their answers were displayed in Table 2, as they typed them. Thus, in some texts, it is possible to see abbreviations or spellings of words that do not follow the standard norm of English grammar, however, we kept the original texts to be faithful to what we collected in the research. We emphasize that this pattern was adopted for the other tables in this article where we present texts typed by the students.

Table 2.

Some suggestions from students about the illustrative didactic materials to be created.

	Some answers from students
A1	One way to make it more interesting is to incorporate interactive elements, such as QR codes that users can scan to access detailed information or even historical curiosities.
A2	Something more interactive, something that makes students remember, like a rhythm of a song.
A3	As a student, sometimes monotony prevents me from memorizing subjects, but more informative periodic tables or ones with superheroes to illustrate the elements would be a cool difference and would usually help me learn the subject more efficiently.
A4	Something that makes it much cooler, like adding heroes.
A5	Explain the periodic table in a more interactive way, so that we can understand it in a better and more practical way.
A6	Add image to the elements.

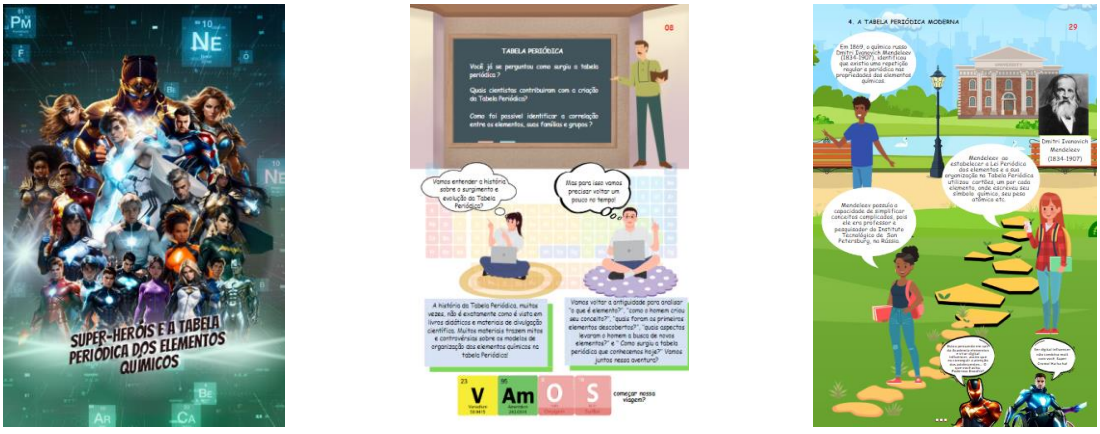
Analyzing the answers, it is clear that students demonstrate interest in studying with a PT with superheroes illustrations and representations. The student A1 suggested the creation of QR codes that direct to historical facts related to chemical elements; student A2 suggested that songs could be associated to facilitate studying; student A3 mentioned that monotony prevents him from memorizing subjects and that a material with superheroes would be a differential for studying.

Second step: analysis and discussion of data from the second questionnaire.

The results of the second questionnaire administered to the students will be analyzed and discussed next, after sharing with students the illustrative didactic materials created (figures 1a and 1b).

Figure 1.

(a) Illustration of some pages of the e-book and (b) images of some letters from the Periodic Table.



(a)

(b)

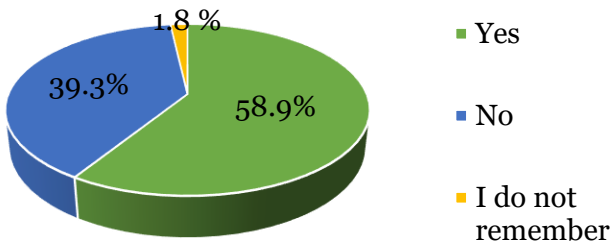
Figure 1a shows some pages of the e-book that presents the various civilizations and scientists who contributed to the discovery of chemical elements and the creation of the Periodic Table. Figure 1b shows some cards created to the Periodic Table, with each chemical element is represented by a superhero with physical characteristics of people we can encounter in our daily lives, such as: black, red-haired, white, mixed-race and disabled people, among other characteristics. This ludic illustrative chemistry material can be found at the electronic address https://atenaeditora.com.br/catalogo/ebook/super-herois-e-a-tabela-periodica-dos-elementos-quimicos.

The second questionnaire also had 10 questions to find out whether the students had already had access to chemistry didactic materials, their opinions on the materials shared in the classroom, what suggestions they could make so that we could improve the materials created, among other questions.

The first question asked “Have you ever had access to chemistry materials (books, notebooks, etc.) illustrating the Periodic Table?”. The results of this question are shown in graph 4 (This question is similar to the one in the first questionnaire and we decided to keep it because new students were present in the classes from the first visit to the schools):

Graph 4.

Data obtained for the first question of the second questionnaire.



It is noted that 58.9% of students have already had access to illustrative materials that address the PT content. However, 39.3% of students have not yet had access to this type of material. When we compare it with the data from the first question of the first questionnaire,

we see that the students who had not had access to illustrative materials were 36.2%, that is, there was a 3.1% increase in students who did not have access to this type of material.

These data show that we need to encourage the production and distribution of these materials in schools because, as demonstrated in the research of Amaral and Tavares (2020, p. 2), these materials, in addition to being entertaining, make classes dynamic and help students develop the capacity for analysis and reflection, enhancing and leading to meaningful learning.

The second question sought to know "Have you ever bought any illustrative material (books, notebooks, etc.) on the Periodic Table to use in chemistry classes?". For this question, we obtained the following data:

Options	Percentage (%)
Yes	19.6
No	80.4

This question was important to show the students' interest in purchasing chemistry illustrative didactic materials. Thus, we observed that 19.6% of the students had already purchased some kind of illustrative material. We noted that 80.4% of the students did not purchase any type of illustrative material to study chemistry, which may be due to factors such as lack of knowledge of these materials, lack of financial resources, among others.

In the third question, we asked "What did you think of the story about the Evolution of the Periodic Table read in the e-book?". For this question, we obtained the following answers:

Options	Percentage (%)
I liked it a lot	91.1
I did not like it	0
I found it reasonable	8.9

We noted that 91.1% of the students really liked the illustrative material produced about the evolution of PT. While 8.9% found it reasonable and none of the students disapproved of these materials. This shows that students identify with ludic materials with current, illustrative and dynamic language. Cardoso et al. (2022, p. 71) identified that the ludicity and popularity of this type of material among young people facilitates acceptance by students, aiming at the construction of more flexible and dynamic knowledge of those involved.

The fourth question (which complements the third question) asked "If in the previous question you answered "I didn't like it" or "I found it reasonable", what do you suggest we improve the illustrative materials?". For this question, we put some suggestions from the students in table 3. The identifications from A1 to A6 represent the students, but not necessarily the numerical order of their answers.

Table 3.

Some suggestions given by students to improve the illustrative materials produced.

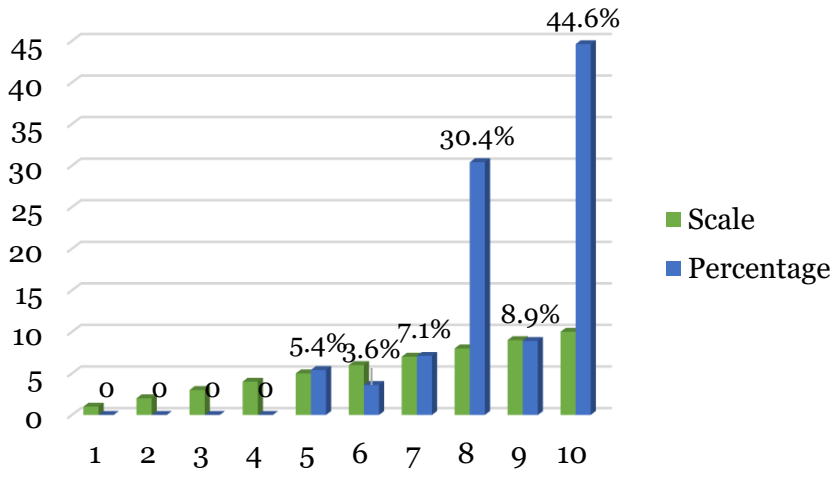
	Some suggestions from students
A1	There is nothing to improve.
A2	It's good to understand.
A3	The project was really cool, it's really interesting to study with illustrations.
A4	Add that each superhero was the one who discovered their own element, and with the discovery, they kind of merged with the element, since it was something new, and gained their powers that way.
A5	The book cover could be improved, put everyone's face on the cover and in the middle put the phrase that is already on the cover.
A6	Put a part of the story that demonstrates how each superhero came about and that makes sense without delay, that catches the attention of everyone who will read it, of course explain how each element works and how to use it in battle and change some names to draw attention and some could have weapons that collaborate with the characters, and draw attention and explain how each element works and call everyone's creativity.

Analyzing the students' texts, we noticed that they approved the ludic materials created and made suggestions for improving the material developed, which shows that students are interested in chemistry content; we just need to make something different and interesting available in class.

The fifth question asked the following inquiry: "Regarding the content of the Periodic Table, on a scale of 0 to 10, is it more interesting to study with an illustrated book?". Graph 5 shows the results obtained for this question:

Graph 5.

Data obtained for the fifth question of the second questionnaire.

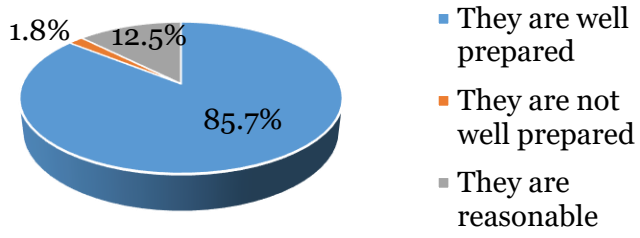


We noticed that scales 8 and 10 were the most indicated, demonstrating that students are interested in studying with more illustrative and dynamic didactic materials. According to Aragão et al. (2023, p. 17), illustrative materials stimulate debates, writing and reading, and allow students to exercise their creative skills, graphic representation and development of ideas in learning.

The sixth question asked "What is your point of view on the cards that represent each chemical element?". For this question, we obtained the data contained in graph 6:

Graph 6.

Data obtained for the sixth question of the second questionnaire.



For 85.7% of the students, the cards about the elements of the Periodic Table were well-designed, while 12.5% found them reasonable, and only 1.8% did not find them well-designed. With the results of this question and the information obtained for the 4th question, we can make the suggested adjustments and meet the students' concerns.

In the seventh question, we seek to know "Is the information contained in the cards of the Periodic Table easy to understand?". The results of this question are presented below:

Options	**Percentage (%)**
Yes	89.3
No	0
Partly	10.7

It can be seen that 89.3% of the students considered the information contained in the cards easy to understand, while 10.7% thought that the cards were easy to understand, and no student said that they were difficult to understand. To complement this issue, we asked question 8: "If you answered 'No' or 'Partly' in the previous question, what could be corrected or changed?", and for this question, we obtained the answers contained in table 4, with the identifications A1 to A6 representing the students, but not the numerical order of their answers.

Table 4.

Some of the students' answers to question eight.

Some answers from students	
A1	They are easy, I would just change the font size, if someone has vision problems it is difficult to understand.
A2	It would be nice to put each person's initial on their chest.
A3	Reduce the information a little (be more concise).
A4	Use language that is easier to read.
A5	Even though there are different ways that people can understand, it is always difficult to understand some elements.
A6	Only the information about the superheroes, and how the powers of each element work needs to be explained better.

The students' suggestions about the illustrative materials are indications of what we can improve in the illustrative materials created, to meet the students' concerns, since the didactic materials created are for them.

For the ninth question, we wanted to know "Did you like the idea of using superheroes to represent the chemical elements to study the periodic table?" For this question, we had the following results:

Options	Percentage (%)
Yes	98.2
No	1.8

It was observed that 98.2% of the students liked the proposal of illustrative material to study the PT content using superheroes representing the chemical elements. Borges et al. (2020, p. 16) mention that illustrative materials can be a viable and useful didactic alternative to assist the teaching-learning process because they facilitate the visualization and application of chemical concepts and processes in everyday life.

In the tenth question, we addressed the following question "Would you like to receive this illustrative material when it is finished?", and for this question, we obtained the following data:

Options	Percentage (%)
Yes	96.4
No	3.6

As can be seen, 96.4% of the students are interested in receiving the chemistry didactic materials once they are finished, while only 3.6% do not want to receive them. At the end of the production of the didactic materials, a socialization will be held with all the students, including those who responded that they were not interested in receiving the material.

Conclusions

We found that 96.9% of students would like to receive free illustrative chemistry materials, 76.3% showed interest in using a more illustrative PT, with information about everyday life, and 88.4% of students found it interesting to establish a relationship between the PP content and superheroes.

We observed that 91.1% of students really liked the illustrative materials produced about the evolution of PT; 85.7% found the cards about the PT elements to be well-designed, and 89.3% considered the information contained in the cards easy to

understand, and 96.4% are interested in receiving the illustrative chemistry materials once they are finished.

The information obtained shows that students are interested in readings with illustrative materials that are easy to read, dynamic and objective, thus, we believe that the illustrative materials produced can contribute to the learning of chemistry, as well as contribute to other researchers who are dedicated to teaching chemistry.

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Declaration of Conflict of Interest

All authors declare that they have no conflict of interest in this study.

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