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Chocolate mousse: Physical chemistry in the formative itinerary of the new high school

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ABSTRACT
The teaching of Natural Sciences becomes increasingly demanding in the sense that students can assimilate scientific knowledge. The experimental activity of Physical Chemistry, in the school environment, constitutes a space that enhances the cognitive and educational aspects of the students. In this sense, the formative itineraries must guarantee the appropriation of knowledge, as well as the use of methodologies that favor the protagonism of youth. For the development of this work, a documentary research was carried out in the references that guide the teaching of physical chemistry, considering the New High School. For this, the study of the National Common Curricular Base and the Gaucho Curricular Reference was carried out, as well as the research in scientific articles about the teaching of physical chemistry in basic education. This proposal fits into the curricular arrangement Natural Sciences and its technologies, in the structuring axis Scientific Investigation, and aims to teach the concepts of physical chemistry, through the production of a classic chocolate mousse. The target audience was students of the 2nd year of High School. In this work it was decided to produce a classic chocolate mousse, as an experimental strategy to learn and teach physical chemistry. Within the three specific competencies of the Area of Natural Sciences and its Technologies, it can be observed that Chemistry is present in all specific skills, whether in the form of Organic Chemistry, Inorganic Chemistry, Physical Chemistry or Analytical Chemistry. Thus, chemical experimentation in the school environment provided the student to relate the objects of study of physical chemistry through observations, comparisons, generalizations and conclusions, integrating theoretical knowledge into the context of everyday life.

Keywords: Teaching, Formative Itinerary, Physical Chemistry, Chocolate Mousse.

1 INTRODUCTION

The teaching of Natural Sciences becomes increasingly demanding in the sense that students can assimilate scientific knowledge. In this scenario, the practical-experimental activity of Chemistry in the school environment constitutes a space that enhances the cognitive, educational and motivational aspects of the students, as well as integrates theory and practice, thought and action.

Rionda Sanchez (2009), describes that scientific knowledge is the product of direct or indirect human action on objects and phenomena at a given time.

The relationship between teaching and learning is intense, because when you teach something, you learn more, stimulating and strengthening knowledge. Physical chemistry is one of the three main branches of chemistry. Several daily actions involve physical-chemical knowledge, from cooking a food, producing a sweet, personal hygiene, making a bread, among others.

The great difficulty on the part of high school students in understanding many important concepts of Chemistry compromises the learning of these students (SANTOS et al., 2013).

According to Silva et al. (2017), this difficulty is further aggravated when it comes to physical chemistry, an area of chemistry that is studied by high school students. This is partly due to a lack of mathematical basis. The difficulties with simple calculations compromise the assimilation of the concepts of Physical Chemistry. A part of the learning process is broken by a lack of skill with mathematics.

With this, this work aims to teach the concepts of physical chemistry, through the production of a classic chocolate mousse.

2 THEORETICAL CONTRIBUTION

2.1 HIGH SCHOOL NORMATIVE DOCUMENTS

According to Brasil (2017), the curriculum of the new high school is composed of the National Common Curricular Base (BNCC) and Formative Itineraries, which were organized through the offer of different curricular arrangements, according to the relevance to the local context and the possibility of the education systems, namely:

I – languages and their technologies;

II – mathematics and its technologies;

III – natural sciences and their technologies;

IV – applied human and social sciences;

V – technical and professional training.

All BNCC skills were defined taking as reference the limit of 1,800 hours of the total workload of each stage (LDB, 1996). Figure 1 represents the general competencies of basic education according to the BNCC.

Figure 1: General competencies of Basic Education – New High School

Source: prepared by the authors, adapted from Brazil (2017).

The curricula, competencies and skills of BNCC, constitute the basic general formation, articulated to the Formative Itineraries as an inseparable whole, under the terms of DCNEM (Opinion and Resolution CNE / CEB No. 3/2018).

2.1.1 National Common Curricular Base and Training Itineraries

Considering the changes in the LDB, due to Law No. 13,415/2017, there is the transition from the single model of high school curriculum to a diversified and flexible model, which is composed of Formative Itineraries.

In this context, it is necessary to reorganize curricula and pedagogical proposals, which are essential to education systems, school networks and schools.

The Formative Itineraries are strategic for the flexibility of the curricular organization of High School, because they allow options of choice to the students, since they can be structured with a focus on an area of knowledge, in the technical and professional training or, also, in the mobilization of competences and abilities of different areas, composing the integrated itineraries, in the terms of the DCNEM. The Formative Itinerary of the area, which has interlocution with physical chemistry, is described below:

> III – natural sciences and their technologies: deepening of structuring knowledge for the application of different concepts in social and work contexts, organizing curricular arrangements that allow studies in astronomy, metrology, general, classical, molecular, quantum and mechanical physics, instrumentation, optics, acoustics, chemistry of natural products, analysis of physical and chemical phenomena, meteorology and climatology, microbiology, immunology and parasitology, ecology, nutrition, zoology, among others, considering the local context and the possibilities offered by education systems (BRASIL, 2017).

The Formative Itineraries must ensure the appropriation of cognitive procedures and the use of methodologies that favor youth protagonism and must be organized around one or more of the following structuring axes (BRASIL, 2017):

> I – scientific investigation: supposes the deepening of foundational concepts of the sciences for the interpretation of ideas, phenomena and processes to be used in research procedures aimed at coping with everyday situations and local and collective demands, and the proposition of interventions that consider local development and the improvement of the quality of life of the community;
> II – creative processes: suppose the use and deepening of scientific knowledge in the construction and creation of experiments, models, prototypes for the creation of processes or products that meet the demands for the resolution of problems identified in society;
> III – mediation and sociocultural intervention: suppose the mobilization of knowledge from one or more areas to mediate conflicts, promote understanding and implement solutions to issues and problems identified in the community;
> IV – entrepreneurship: supposes the mobilization of knowledge from different areas for the formation of organizations with varied missions focused on the development of products or provision of innovative services with the use of technologies (Resolution CNE / CEB No. 3/2018).

Figure 2 shows the proposed articulation for the Formative Itinerary with the discipline of Chemistry, according to the Gaucho Curricular Reference for High School (2021).

Figure 2: Articulation of Chemistry and the Formative Itinerary, according to RCG.

NEW HIGH SCHOOL	
Specific Disciplines	Formative Itinerary
Workload to fulfill the content of the general training	Work contextualized with the specific discipline
Chemistry	Opt for a Structuring Axis
Workload: 1st year: 2 hours/week 2nd year: 2 hours/week 3rd year: indefinite	

Source: Prepared by the authors, adapted RS (2021).

2.1.2 The Area of Natural Sciences and its Technologies

In Basic Education, it can be stated that the Area of Natural Sciences and its Technologies should contribute to the construction of contextualized knowledge, which encourage the protagonism of students, in order to create alternatives to make judicious use of various technologies.

Chart 1 describes the specific competencies and skills of high school, according to the BNCC (BRASIL, 2017).

Table 1: Specific competencies and skills of High School.

Specific competence	Specific skills
Analyze natural phenomena and technological processes, based on the relations between matter and energy, to propose individual and collective actions that improve production processes, minimize socio-environmental impacts and improve living conditions at the local, regional and/or global level.	(EM13CNT101) Analyze and represent the transformations and conservations in systems that involve amount of matter, energy and movement to make predictions in everyday situations and productive processes that prioritize the rational use of natural resources. (EM13CNT102) Perform forecasts, evaluate interventions and/or build prototypes of thermal systems aimed at sustainability, based on the analysis of the effects of thermodynamic variables and the composition of natural and technological systems. (EM13CNT103) Use knowledge about radiation and its origins to evaluate the potential and risks of its application in everyday equipment, in health, in industry and in the generation of electricity. (EM13CNT104) Evaluate potential damages of different materials and products to health and the environment, considering their composition, toxicity and reactivity, as well as the level of exposure to them, positioning themselves critically and proposing individual and/or collective solutions for the proper use of these materials and products. (EM13CNT105) Analyze the cycling of chemical elements in soil, water, atmosphere and living beings and interpret the effects of natural phenomena and human interference on these cycles, to promote individual and/or collective actions that minimize harmful consequences to life. (EM13CNT106) Evaluate technologies and possible solutions to the demands that involve the generation, transportation, distribution and consumption of electricity, considering the availability of resources, energy efficiency, cost/benefit ratio, geographical and environmental characteristics, waste production and socio-environmental impacts.
Construct and use interpretations about the dynamics of Life, Earth and the Cosmos to elaborate arguments, make predictions about the functioning and evolution of living beings and the Universe, and ground ethical and responsible decisions.	(EM13CNT201) Analyze and use scientific models, proposed in different times and cultures to evaluate different explanations about the emergence and evolution of Life, the Earth and the Universe. (EM13CNT202) Interpret forms of manifestation of life, considering its different levels of organization (from molecular composition to biosphere), as well as the favorable environmental conditions and the limiting factors to them, both on Earth and on other planets. (EM13CNT203) Evaluate and predict the effects of interventions on ecosystems, living beings and the human body, interpreting the mechanisms of life maintenance based on the cycles of matter and the transformations and transfers of energy. (EM13CNT204) Elaborate explanations and predictions regarding the movements of objects on Earth, in the Solar System and in the Universe based on the analysis of gravitational interactions. (EM13CNT205) Use notions of probability and uncertainty to interpret predictions about experimental activities, natural phenomena and technological processes, recognizing the explanatory limits of the sciences. (EM13CNT206) Justify the importance of the preservation and conservation of biodiversity, considering qualitative and quantitative parameters, and evaluate the effects of human action and environmental policies to ensure the sustainability of the planet. (EM13CNT207) Identify and analyze vulnerabilities linked to the contemporary challenges to which young people are exposed, considering the physical, psychoemotional and social dimensions, in order to develop and disseminate actions of prevention and promotion of health and well-being.
Analyze problem situations and evaluate applications of scientific and technological knowledge and their implications in the world, using procedures and languages specific to the Natural Sciences, to propose solutions that consider local, regional and/or global demands, and to communicate their findings and conclusions to varied	(EM13CNT301) Construct questions, elaborate hypotheses, predictions and estimates, employ measuring instruments and represent and interpret explanatory models, data and/or experimental results to construct, evaluate and justify conclusions in coping with problem situations from a scientific perspective. (EM13CNT302) Communicate, to varied audiences, in various contexts, results of analyses, research and/or experiments – interpreting graphs, tables, symbols, codes, classification systems and equations, elaborating texts and using different media and digital information and communication technologies (TDIC) – in order to promote debates around scientific and/or technological themes of sociocultural relevance. (EM13CNT303) Interpret texts of scientific dissemination that deal with themes of the Natural Sciences, available in different media, considering the presentation of the data, the consistency of the arguments and the coherence of the conclusions, aiming to build strategies for the selection of reliable sources of information.

audiences, in various contexts and through different media and digital information and communication technologies (TDIC).	(EM13CNT304) Analyze and debate controversial situations about the application of knowledge in the area of Natural Sciences (such as DNA technologies, stem cell treatments, armaments production, forms of pest control, among others), based on consistent, ethical and responsible arguments, distinguishing different points of view. (EM13CNT305) Investigate and discuss the misuse of knowledge from the Natural Sciences in the justification of processes of discrimination, segregation and deprivation of individual and collective rights to promote equity and respect for diversity. (EM13CNT306) Evaluate the risks involved in daily activities, applying knowledge of the Natural Sciences, to justify the use of equipment and safety behaviors, aiming at physical, individual and collective integrity, and socio-environmental. (EM13CNT307) Analyze the specific properties of materials to assess the suitability of their use in different applications (industrial, everyday, architectural or technological) and/or propose safe and sustainable solutions. (EM13CNT308) Analyze the functioning of electrical and/or electronic equipment, computer networks and automation systems to understand contemporary technologies and assess their impacts. (EM13CNT309) Analyze socio-environmental, political and economic issues related to the dependence of the current world on fossil resources and discuss the need to introduce alternatives and new energy and materials technologies, comparing different types of engines and production processes of new materials. (EM13CNT310) Investigate and analyze the effects of infrastructure programs and other basic services (sanitation, electricity, transportation, telecommunications, vaccination coverage, primary health care and food production, among others) and identify local and/or regional needs in relation to these services, in order to promote actions that contribute to improving the quality of life and health conditions of the population.

Source: prepared by the authors, adapted from Brazil (2017).

According to Chart 2, it can be observed that the specific skills can be worked during the three years of High School, corroborating with the Gaucho Curricular Reference (RS, 2021).

> From the three specific competencies, which should be worked in the light of the ten general competencies of Basic Education, the skills of the area are developed, which are proposed in the BNCC and which are brought in Chart 1, complemented by the skills suggested for the gaucho curriculum, which can be worked in one, two or three years of High School, according to the suggestions below or at the discretion of the teacher in his planning, with a view to the specificities of the territory and which are listed in the column Skills RS (RS, 2021).

Considering that the main objective of high school is to deepen the learning of elementary school, train students for the exercise of citizenship and prepare them for the selection processes, the new High School has a greater focus on the disciplines of Portuguese and mathematics. In the second year of high school the discipline of Chemistry, seeks to direct knowledge about gases, solutions, colligative properties and thermochemistry in addition to the study of inorganic reactions and stoichiometry. It is popularly stated that physical chemistry is inserted in the contents of the second year of high school.

Thus, Chart 2 describes the specific skills to be developed in the 2nd year of high school within Physical Chemistry.

Table 2: Specific skills to be developed in the 2nd year of High School within Physical Chemistry.

Specific skills
(EM13CNT101) Analyze and represent the transformations and conservations in systems that involve amount of matter, energy and movement to make predictions in everyday situations and productive processes that prioritize the rational use of natural resources. (EM13CNT102) Perform forecasts, evaluate interventions and/or build prototypes of thermal systems aimed at sustainability, based on the analysis of the effects of thermodynamic variables and the composition of natural and technological systems. (EM13CNT103) Use knowledge about radiation and its origins to evaluate the potential and risks of its application in everyday equipment, in health, in industry and in the generation of electricity. (EM13CNT104) Evaluate potential damages of different materials and products to health and the environment, considering their composition, toxicity and reactivity, as well as the level of exposure to them, positioning themselves critically and proposing individual and/or collective solutions for the proper use of these materials and products.
(EM13CNT203) Evaluate and predict the effects of interventions on ecosystems, living beings and the human body, interpreting the mechanisms of life maintenance based on the cycles of matter and the transformations and transfers of energy. (EM13CNT205) Use notions of probability and uncertainty to interpret predictions about experimental activities, natural phenomena and technological processes, recognizing the explanatory limits of the sciences. (EM13CNT206) Justify the importance of the preservation and conservation of biodiversity, considering qualitative and quantitative parameters, and evaluate the effects of human action and environmental policies to ensure the sustainability of the planet.
(EM13CNT308) Analyze the functioning of electrical and/or electronic equipment, computer networks and automation systems to understand contemporary technologies and assess their impacts. (EM13CNT309) Analyze socio-environmental, political and economic issues related to the dependence of the current world on fossil resources and discuss the need to introduce alternatives and new energy and materials technologies, comparing different types of engines and production processes of new materials. (EM13CNT310) Investigate and analyze the effects of infrastructure programs and other basic services (sanitation, electricity, transportation, telecommunications, vaccination coverage, primary health care and food production, among others) and identify local and/or regional needs in relation to these services, in order to promote actions that contribute to improving the quality of life and health conditions of the population.

Source: prepared by the authors, adapted from Brazil (2017).

3 METHODOLOGY

3.1 RESEARCH METHODOLOGY

For the development of this work, a documentary research was carried out in the references that guide the teaching of physical chemistry in the New High School. For this, it was based on the study of the National Common Curricular Base and Gaucho Curricular Reference, and on other documents of normative character of teaching.

In addition, research was carried out in scientific articles about the teaching of physical chemistry.

The proposal fits into the curricular arrangement of Natural Sciences and its technologies, and the structuring axis Scientific Research.

3.2 TEACHING METHODOLOGY

The target audience was students of the 2nd year of High School.

In this work it was decided to produce a classic chocolate mousse, as an experimental strategy to learn and teach physical chemistry, in the New High School.

Next, in Table 3, we have the recipe, containing the ingredients and method of preparation of the classic chocolate mousse.

Table 3: Recipe and method of preparation of the classic chocolate mousse.

Makings	2 creams 400 g chopped dark chocolate 6 egg whites 10 tablespoons sugar
Method of preparation	1º) Add the egg whites to the mixer dish. 2º) Beat the egg whites in snow point.  3º) When the egg whites are at the foam point, add the sugar.  4º) Beat until it looks like meringue, in the form of an emulsion.  5º) Chop 400 g of chocolate in smaller portions. 6º) Place the chocolate in a container that can go to the microwave.  7º) Insert in the microwave and heat at low power until melting. 8º) Stir the chocolate from the container, slowly. 9º) Add 01 sour cream and stir slowly. Insert 01 more cream.

	  10º) If you still have pieces of chocolate without melting, insert another 1 minute in the microwave. 11º) Add the white in snow, slowly, next to the chocolate, stirring from bottom to top, slowly.  12º) Serve the mousse in jars and refrigerate for 3 hours.  13°) The mousse is ready!

Source: Prepared by the authors and own record.

For the production of the classic chocolate mousse, a set of planned activities in the form of moments is suggested, which favor the pedagogical practice, according to Chart 4.

Table 4: Moments and description of activities.

A MOMENT	DESCRIPTION
First	**Student instigation** In this first moment, a dialogue about the recipe of the classic chocolate mousse is suggested, as well as a reflection on the quantities of ingredients, calories, preparation time and measurements. Also, photos of the previously prepared mousse are presented.
2nd	**Contextualization of the theoretical content** The contextualization of the theoretical content can be done using a traditional and expository class of topics about physical chemistry, such as chemical equilibrium, types of dispersions, chemical kinetics, thermochemistry, stoichiometry and chemical reaction.
Third	**Production of classic chocolate mousse** The production of the classic chocolate mousse should be carried out according to table 3.

4th	**Interlocution of the activity with the guiding documents** At this point, it is suggested a reflection of the specific competencies and abilities of the New High School that may be associated with the experimental activity.

Source: Prepared by the authors.

4 RESULTS AND DISCUSSIONS

In this chapter, it is emphasized that table 4 highlights a set of planned activities in the form of moments, which can be used in pedagogical practice.

The recipe of the classic chocolate mousse was prepared by the authors, according to table 3, as a previous test, in order to verify the details of each stage of the preparation.

At the moment of instigation of the student, the dialogue will stimulate reflection, the need to confront ideas and to position oneself in the face of difficult subjects, contributing to the resolution of problems and to the cognitive development of the students.

Considering the specific skills, possible to be developed in the 2nd year of High School within the Physical Chemistry, from the production of the classic chocolate mousse, some contents and sub contents were listed, which are related to each stage for the experimental activity and contextualized with the proposal.

Figure 3 represents an illustration of the concept map, made by the professor, professor of the discipline of Chemistry.

Figure 3: Concept map about the contents and sub-contents for each stage of the procedure.

Source: Own authorship.

Chart 5 outlines the contents and sub-contents of physical chemistry addressed at each stage of the chocolate mousse manufacturing process.

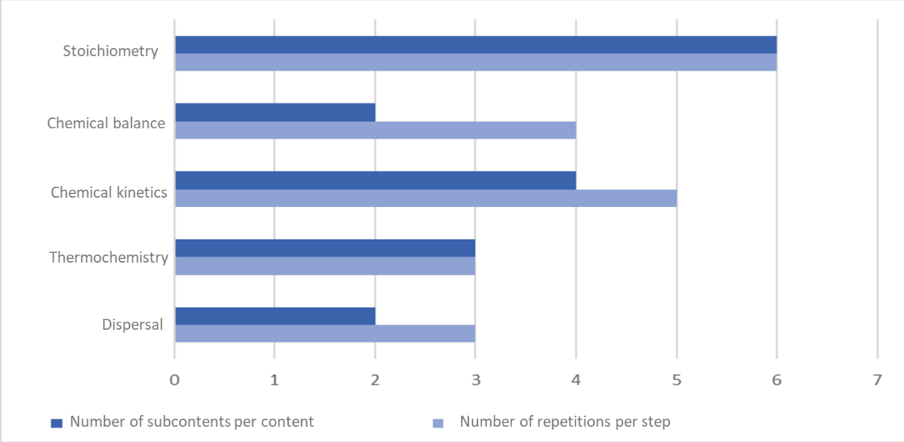
Table 5: Contents and sub-contents of physical chemistry in each stage.

STAGE	CONTENT	SUB CONTENT	
Beat the egg whites to the point of meringue	Dispersion	Emulsion	
	Thermochemistry	Internal energy	
	Chemical kinetics	Reaction speed	Activation power
	Chemical equilibrium	Factors that shift the balance	
Chop the chocolate into small pieces	Chemical kinetics	Factors that affect the speed of the reaction	
Put the chocolate in a container that can go to the microwave	Stoichiometry	Reagent and product	
Add the egg whites in a mixer	Stoichiometry	Definition	Chemical equation
Beat the egg whites in snow point	Chemical equilibrium	Definition	
	Dispersion	Foam	
	Chemical kinetics	Definition	Reaction speed
Add the sugar to the egg whites in snow	Stoichiometry	Chemical reaction	Stoichiometric calculation
Heating chocolate in the microwave	Thermochemistry	Heat	Enthalpy
Stir the chocolate slowly	Chemical kinetics	Activation power	Reaction speed
Add the sour cream	Stoichiometry	Chemical reaction	Stoichiometric calculation
	Chemical equilibrium	Factors that shift the balance	
Add the white in snow	Stoichiometry	Chemical reaction	
	Dispersion	Emulsion	
Serve the mousse and take the refrigerator	Thermochemistry	Heat	Enthalpy
	Chemical equilibrium	Factors that shift the balance	
	Stoichiometry	Yield	
	Chemical kinetics	Reaction speed	Factors that affect the speed of the reaction

Source: Prepared by the authors.

Graph 1 shows the interpretation of table 5, according to the contents and sub contents for each stage of the activity.

Graph 1: Interpretation according to the contents and sub contents for each stage of the activity.



Source: Own authorship.

4.1 INTERLOCUTION OF THE ACTIVITY WITH THE GUIDING DOCUMENTS

Table 6 below highlights the interlocution of the proposed activity with the specific skills of BNCC, which can be achieved after developing the practice.

Table 6: Interconnection of the contents of physical chemistry in with the specific skills.

Content	Specific skills
Dispersion	EM13CNT101
Thermochemistry	EM13CNT101 - EM13CNT102 - EM13CNT203
Chemical kinetics	EM13CNT101 - EM13CNT102 - EM13CNT203
Chemical equilibrium	EM13CNT102
Stoichiometry	EM13CNT101

Source: Own authorship.

It is worth mentioning that this proposal also has the potential to be applied in the final years of elementary school, since it contemplates some specific skills related to the curricular component sciences.

5 FINAL CONSIDERATIONS

The Physical Chemistry of Traditional High School is concentrated in the 2nd year, but in the New High School it is dispersed over the three years.

Within the three specific competencies of the Area of Natural Sciences and its Technologies, it can be observed that Chemistry is present in all specific skills, whether in the form of Organic Chemistry, Inorganic Chemistry, Physical Chemistry or Analytical Chemistry.

Thus, chemical experimentation in the school environment provides students with the ability to relate the objects of study of Chemistry through: observations, comparisons, generalizations and conclusions, integrating theoretical knowledge into the context of everyday life.

According to Borges (2002) and Laburú (1999), the central aspect in learning from practical activities is not where it happens, but how and for what they are performed. For, according to the authors, more important than a sophisticated and specific experimental apparatus, is the definition of objectives to be achieved with this type of class and clarity regarding the role of experimentation in student learning.

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