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Health education in the Moroccan high school physics-chemistry curriculum: current situation, prospects and proposals

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Abstract

Today, people are living longer, but are more exposed to various forms of disease. Prevention strategies in schools must therefore be at the heart of any government program aimed at maintaining the quality of education and promoting health in schools. The aim of this study is to investigate the inclusion of health education themes in the Moroccan high school physics-chemistry curriculum, in order to analyze the pedagogical orientations in the physics-chemistry teacher's guides. Our methodology consists in evaluating the objectives relating to health education in the physics-chemistry curricula of the secondary college cycle, so we have developed a valid and reliable questionnaire with an alpha Cronbach index of $\alpha = 0.92$ for the benefit of secondary school physics-chemistry teachers. The results show a low percentage of health-related objectives in teaching guidelines as well as in physics-chemistry textbooks. Furthermore, the questionnaire results show that 94% of physics-chemistry teachers consider health education to be an important part of their basic training. Moreover, 70% of participants strongly agreed that health education in physics-chemistry curricula can prevent future illnesses. Finally, 82% believe that the current physics-chemistry curriculum cannot educate for health. The adoption of health education in physics and chemistry curricula is a necessity today more than ever in order to avoid or delay diseases.

Keywords: Chemistry, curricula, education, health, physics

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1. Introduction

The teaching of physics and chemistry in secondary school can explain many of the phenomena of our daily lives. It involves the transmission of scientific knowledge based on natural or artificially induced physical or chemical phenomena [1]. As a result, these lessons enable learners to understand facts through experimentation, and contribute to the development of students' ability to take a critical, informed look at a range of phenomena; they combat arbitrary representations and unfounded beliefs, and promote scientific analysis and reasoning. In addition, according to UNESCO and UNICEF, a national curriculum should focus on respect for the environment, the preservation of students' health and the health of others. These international recommendations are behind the growing interest in health education in schools over the past decade [2]. In 2012, the WHO stipulated that the school is a place of life where the social, physical, mental and psychological dimensions of health are inseparable. In Europe, health education is positioned differently from country to country. In Finland and Ireland, it is an independent school subject [3]; in France, it is a cross-cutting area associated with citizenship, or with personal development, as in Portugal. In other countries, such as Quebec, health education is present both as a discipline associated with physical education and as a cross-curricular area. In Morocco, health education can be seen as a cross-disciplinary approach [4]. At the same time, the objectives and teaching/learning methods of health education have evolved considerably. In the past, health education was aimed

at prevention and behavior change. Today, it is increasingly focused on empowering people to take charge of their own health, and to learn how to live and thrive in an ever-changing society [5]. As health is a daily concern in today's society, it seems appropriate to address this issue from elementary school onwards, to help children better understand and grasp the expectations and recommendations in this area [6].

In Morocco, the advent of the strategic vision of reform 2015-2030, drawn up by the Moroccan Higher Council for Education and Training, has placed socialization and values education among the essential functions of the Moroccan school [7], and the promotion of the individual and society one of the important foundations of this reform. This study is a contribution to the same logic, aiming to promote the pedagogical and educational action of schools through health education [8]. In 2009, the Moroccan Higher Education Council defined physics-chemistry in secondary education as a scientific subject that starts with experimentation, enabling students to acquire scientific knowledge and empirical and theoretical skills in a variety of fields. This scientific knowledge also plays a decisive role in students' career choices [9]. So, how can high school physics and chemistry programs contribute to health education? How can physics and chemistry be used in health education? Can students adopt healthy attitudes towards their health by introducing physics and chemistry for health into the curriculum? The main objective of this study is to analyze the physics and chemistry curricula of the secondary school cycle in Morocco in order to highlight the importance of the health dimension in the physics and chemistry disciplines.

2. Materials and methods

2.1 Study design

The aim of this evaluative study is to analyze pedagogical orientations through teacher guides and to analyze physics-chemistry textbooks, with a view to opening up perspectives for didactic research that show the important link between physics-chemistry programs and the dimension of health and the environment. Indeed, all scientific research requires a precise methodological approach to enable the researcher to collect, analyze and interpret data.

2.2 Study setting

In the present study, we analyzed the guides of physics-chemistry teachers in the secondary college cycle, as well as the textbooks of the same discipline. We also developed a reliable and valid questionnaire for a sample of physics and chemistry teachers in the Rabat-Sale-Kénitra region of Morocco. This region is characterized by the presence of the kingdom's administrative capital, with four provinces and three prefectures according to the Moroccan administrative division. Educational provision in the region is characterized by diversification between the public and private sectors. According to 2020 statistics, the region's school-going population is 1.3 million, with 237 351 students enrolled in 544 secondary schools [10].

2.3 Methods and sampling

To better assess the place of health education in physics-chemistry curricula, we first analyzed the objectives relating to the health dimension in the physics-chemistry teacher's guides for the secondary college cycle (The AL MOUFID teacher's guide to physics and chemistry for three years of secondary school. (Serial number: PICPC 0112320 - Approval date: August 13, 2020)). Secondly, we analyzed the physics-chemistry textbooks of the secondary school cycle (Collection AL MOUFID, Physics-Chemistry, Student's Manual).

With the aim of finding out the views of physics-chemistry teachers on the place of health education in physics-chemistry curricula, we devised a valid and reliable questionnaire by a scientific committee made up of higher education physics and chemistry teachers. This questionnaire is distributed online using "Google form" to physics-chemistry teachers in the study region and consists of four parts: identification of participants, the importance of the health dimension in physics-chemistry curricula, the integration of health education into basic teacher training and the adoption of this education as a school subject.

2.4 Statistical analysis

All data collected were analyzed using (Statistical Package for the Social Sciences) SPSS software version 2.0. We used the alpha Cronbach (α) test to ensure the reliability of our questionnaire.

2.5 Ethical considerations

We have taken into consideration the anonymity and consent of the participants and have obtained all necessary authorizations to carry out this study.

3. Results and Discussions

3.1 *Analysis of pedagogical orientations*

The teacher's guide " ALMOUFID in Physics and Chemistry for the first year of secondary school, Serial number: PICPC 0112320 - Approval date: August 13, 2020" shows that the first year is divided into two parts, each subdivided into chapters (Table 1).

In fact, in order to examine the themes related to health education in this year, we have confined our analysis to the chapters of the first semester, as the second semester focuses on "electricity", and health education may be a little removed from this part, except that the last chapter may, in a way, give instructions for the protection of health and the environment:

- Some dangers of electric current;
- Protecting yourself from the dangers of electric current.

It's true that teaching guidelines, via teachers' guides, are a lever for all pedagogical actions. With this in mind, those in charge of education and training, especially those responsible for curricula, need to guide teachers so that they put learners in a position to question current issues. This is why the health and well-being dimension must be included in all teachers' teaching guides. By way of example.

- The volume of water in the human body;
- The amount of water required by the human body during the day;
- Food contains water.

In analyzing this guide, we note that the notion of health education is absent from the pedagogical orientations of this first year, so we can direct teachers to adopt a context of health and well-being in several chapters of this year, notably the first part:

- The importance of washing hands and body with water (chapter 1);
- Water-borne diseases (chapter 1);
- Characteristics of blood as a liquid (chapter 2);
- The volume of blood in the human body and the geometric shape of vessels (chapter 2);
- The ideal weight of men and women and the method for calculating the body mass index (chapter 2);
- The density of some of the liquids that make up the human body (Chapter 2);
- The method for calculating arterial pressure and its normal values in humans, introducing the concepts of force, pressure and surface area (P= F/S).
- When vessel surface area is reduced by cholesterol molecules and other debris, pressure is increased (Chapter 2);
- Information on some of the atoms and molecules that make up the human body (iron, zinc, calcium...etc). (Chapter 3);
- Knowledge of body temperature and how to measure it (chapter 3) ;

In the second year, as shown in «The AL MOUFID teacher's guide to Physics and Chemistry» for the second year of secondary school (Serial number: PICPC 0112320 - Approval date: August 13, 2020), this year is divided into two parts: the first is subdivided into eight lessons, while the second is subdivided into seven lessons (Table 2). In analyzing this guide, we note that the term "health" is mentioned as a skill targeted by the teaching of physics and chemistry: "Mobilize, in an integrated way, knowledge, methods, techniques and attitudes (concerning the physical and chemical properties of matter, physical and chemical transformations, the models that describe them and the laws that govern them) to solve problem situations linked to the use of natural resources, their rationalization and the preservation of health and the environment" [11]. Therefore, the fourth lesson of the first part aims to teach learners about "the effects of cigarettes on health". In addition, the reasons why incomplete combustion is dangerous: "It leads to the formation of carbon monoxide, an odorless, colorless gas that is toxic to health and the environment" [12].

Similarly, teachers are expected to guide learners through small groups to highlight the main pollutants in the area. "They emphasize the negative practices linked to human and industrial activities that pollute the air, and explain the consequences of air pollution on health and the environment" [13]. In this way, they explain the harmful effects of ground-level ozone pollution on health (stinging eyes, respiratory illnesses, coughing, etc.). In the second part of this guide (light and image), the word health is mentioned only once: "Light enables the biological development of living organisms (human beings, animals, plants, etc.), and the improvement of everyday life: health, lighting, technology, agriculture, animal husbandry, etc.[14] » On the other hand, in the second part, teachers can convey a number of health education educational messages on the physiology and diseases of the eye, etc. In the final year of secondary school, “The AL MOUFID teacher's guide to Physics and Chemistry" in third year (Serial number: PICPC 0112320 - Approval date: August 13, 2020), shows that this year is divided into two parts like its predecessors, with a total of sixteen chapters.

Once again, this year can educate to health in several chapters such as:

- Materials that make up the human body (Chapter 1) ;
- Packaging materials and their effects on health (Chapter 1) ;
- Conduction in the human body (Chapter 2) ;
- Health hazards associated with airborne combustion of organic materials (Chapter 3);
- Notions of PH and the human body (gastric acid as an example) (Chapter 4) ;
- Movement of selected body parts (introduction to biomechanics) (Chapter 8) ;
- Body mass index and ideal weight (Chapter 13) ...etc.

3.2 Health education in high school physics and chemistry textbooks

The Physics and Chemistry student manual for the first year of secondary school consists of two parts: The first is devoted to matter and the environment, while the second is dedicated to the world of electricity.

The first part is divided into five chapters, and each chapter is subdivided into lessons.

In this respect, today's physics-chemistry curricula and pedagogical guidelines consider the renovation of the current pedagogical model to be an inescapable lever in the perspective of making learners' teaching evolve in line with global novelties in order to largely determine: the quality of teaching in its activities and achieve the objectives of the expected change and proposes to :

- Develop didactic tools to guide and help teachers improve their performance in conveying educational messages ;
- Master basic skills by developing learners' knowledge and participatory skills in each teaching cycle;
- Modernize teaching methods to develop learners' thinking and skills in observation, analysis, argumentation and critical thinking - the reasoning to adopt in health education;
- Consider the learner as a true partner of the school in teamwork and extracurricular activities. We need to consider the learner as the ultimate goal of the learning process, encourage him or her to develop a culture of intellectual curiosity, effort and initiative, entrust him or her with research, innovation and management tasks, and develop in him or her a sense of belonging to the school and a sense of duty;
- Identify students in difficulty and organize support and remediation sessions;
- Integrate information and communication technologies into the teaching of physics and chemistry in junior high schools.

Despite the desire expressed by those in charge of education to adopt a textbook that reflects reality, we note that the objectives relating to health education

(Table 3) are very inadequate for conveying educational messages on health-related knowledge and attitudes. In fact, only one objective out of forty relates to health, even though this part of the textbook has the potential to educate about health.

In addition, the Physics and Chemistry student manual for the second year of secondary school is divided into three parts: the first deals with matter and the environment, the second with light and images. Finally, the third part is devoted to electricity. The first part is divided into eight lessons, while the second is subdivided into seven lessons. Table 4 also shows that in the 2nd year of secondary school, the percentage of objectives relating to health education is slightly higher than in the first year. It should be noted that the number of lessons in the second year is the same as in the first. In addition, the 2015 pedagogical guidelines and the specifications drawn up by the Curricula Department confirm that teaching aids are one of the levers for influencing pedagogical action and reinforcing learners' skills. Once the primary cycle has been validated and students move on to the secondary cycle, the CP curricula for the three years of the college secondary cycle emphasize the investigative approach, so that learners acquire more technical skills. This is reflected in the methods described in the teaching guides. Indeed, several approaches are presented, and teaching should encourage learners to adopt a reflexive frame of mind, enabling them to exploit the situations studied in everyday reality. A presentation by the teacher is sometimes necessary, but it should only guide and encourage learners to make research efforts at home. It should not, in general, constitute the main part of a session in an approach that favors the construction of knowledge by the student [15].

The pedagogical approach used in the PC manuals aims to:

- Encourage diversity and argumentation ;
- Adopt the fundamentals of the Competency-based approach, making the student the actor in his or her own learning;
- Analyze errors, trying to determine their origin, and enable students to become aware of their mistakes;
- Give learners the time they need to eliminate bad hypotheses;
- Use information and communication techniques to offer learners multiple pathways to knowledge and diversify teaching media.
- Make students more inquisitive in order to develop their critical faculties;
- Take advantage of incorrect answers to improve performance;
- Encourage creative thinking and control;
- Explain that errors and doubts are the main foundations of learning;
- Encourage the need for teamwork.

On the other hand, the investigative approach enables the acquisition and broadening of knowledge and skills with the aim of developing critical thinking, curiosity, creativity and interest in environmental, scientific and technical progress. The act of teaching is a difficult process that calls on knowledge and facts recognized and structured by the teacher. This pedagogical path leads to a shift from a pedagogy centered on the transmission of knowledge to convey it in answers and performances, to one in which the learner represents the central axis, with the aim of giving young people the impression of asking the questions they themselves must answer: how do they learn, how do they construct or reconstruct knowledge on their own behalf? [16]

In the third and final years of secondary school, the physics-chemistry program consists of three parts:

- Materials;
- Mechanics;
- Electricity.

We have dealt with the first two parts of the textbook, namely materials and mechanics (Table 5).As for the PC manual, we can conclude that it is powerless to educate about health, despite the existence of several themes that can be used to convey educational messages about health and well-being.

3.3 Questionnaire results

Our study showed the participation of 125 physics-chemistry teachers, namely college (66.4%) and qualifying high school (33.6%) teachers. Thus, the population of our study is mainly made up of former teachers: (43.4%) have an average age of over 45 years, (24.1%) have an average age between 36 and 45 years and (32.4%) are under 36 years old. The respondents to our survey, of whom (26.2%) were women and (73.8%) men, covered all the provinces and prefectures of the Rabat-Salé-Kénitra region, with (35.2%) teachers in rural schools and (64.8%) in urban schools. Cronbach's α calculated from SPSS is equal to 0.92. Furthermore, (40.7%) believe that current physics-chemistry curricula enable students to develop personal, social and civic skills, (37.9%) consider that these curricula enable students to learn about their bodies, their health, their behavior and its effects, and only (17.9%) consider that these curricula enable students to acquire the means to take a critical look at their own environment, while (35.2%) declare that none of these propositions is correct.

In addition, (98%) strongly agree that strengthening educational fields related to health education is a priority. In addition, (39.3%) strongly agree and (44.1%) agree that social pressure on core subjects leaves little room for health education, and the majority of teachers report that health education can be included in various disciplines such as life and earth sciences, physical and chemical sciences, physical education. An assessment of the level of competence of physics-chemistry teachers in health education shows that (63%) have an average level, (22%) have a low level and only (15%) indicate a high level. Thus, (56%) have never been trained in health education. In addition, (94.5%) of respondents consider training in health education to be necessary.

Our survey showed that (61.4%) of respondents said that health education is a school activity carried out by specialist teachers. On the other hand, (52.4%) say that health education is the business of health establishments through health professionals, and (44.8%) say that health education is the business of the external environment through partners (associations, organizations, companies, etc.). (Figure 1).

Table 1: Chapters from the physics and chemistry teacher's guide 1st year of secondary school

Chapters	Lessons
Chapter 1 : the water	**Lesson 1** : the water
Chapter 2 : States of matter	**Lesson 2** : The three states of matter
	Lesson 3 : Volumes of liquids and solids
	Lesson 4 : Mass of solids and liquids
	Lesson 5 : Density
	Lesson 6 : the pressure
	Lesson 7 : The particle model of matter
Chapter 3 : physical transformation of matter	**Lesson 8** : Heat and temperature
	Lesson 9 : Changes of state
	Lesson 10 : model and material transformation
Chapter 4 : blends	**Lesson 11** : Homogeneous and heterogeneous mixing
	Lesson 12 : Dissolution
	Lesson 13 : Separating the constituents of a mixture
	Lesson 14 : The pure body and its characteristics
Chapter 5 : Water treatment	**Lesson 15 :** Water treatment

Table 2: Parts of the 2nd year college physics and chemistry teacher's guide

Parts	Lessons
Part 1 : Materials and environment	**Lesson 1** : The air around us
	Lesson 2 : Air and its constituents
	Lesson 3 : Molecules and atoms
	Lesson 4 : Combustion processes
	Lesson 5 : The chemical reaction
	Lesson 6 : The laws of chemical reaction
	Lesson 7 : Natural and synthetic materials
	Lesson 8 : Air pollution
Part 2 : Light and image	**Lesson 1** : The light that surrounds us
	Lesson 2 : Light sources and receptors
	Lesson 3 : Light and color
	Lesson 4 : Light propagation
	Lesson 5 : Applications of light propagation
	Lesson 6 : Thin lenses
	Lesson 7 : study of some optical instruments

Table 3: Percentage of health education objectives in the physics and chemistry textbook, 2nd year of secondary school

Part	Chapter	Lesson	Total objectives (2)	Total objectives relating to health education (1)	Percentage of (1) to (2)
1	**1**	**1**	**5**	**1**	**20%**
	2	**2**	**2**	**0**	**0%**
		3	**3**	**0**	**0%**
		4	**3**	**0**	**0%**
		5	**3**	**0**	**0%**
		6	**6**	**0**	**0%**
		7	**2**	**0**	**0%**
	3	**8**	**2**	**0**	**0%**
		9	**2**	**0**	**0%**
		10	**1**	**0**	**0%**
	4	**11**	**3**	**0**	**0%**
		12	**2**	**0**	**0%**
		13	**1**	**0**	**0%**
		14	**2**	**0**	**0%**
	5	**15**	**3**	**0**	**0%**
Total	**5**	**15**	**40**	**1**	**02,50 %**

Table 4: Percentage of health education objectives in the physics and chemistry textbook, 1st year of secondary school

Part	Lesson	Total objectives (2)	Total health education objectives (1)	Percentage of (1) to (2)
1	**1**	**4**	**0**	**20%**
	2	**3**	**0**	**0%**
	3	**6**	**0**	**0%**
	4	**6**	**2**	**33,33%**
	5	**3**	**0**	**0%**
	6	**4**	**0**	**0%**
	7	**5**	**0**	**0%**
	8	**3**	**3**	**100%**
2	**1**	**1**	**0**	**0%**
	2	**4**	**0**	**0%**
	3	**2**	**0**	**0%**
	4	**7**	**0**	**0%**
	5	**5**	**0**	**0%**
	6	**9**	**0**	**0%**
	7	**5**	**2**	**40%**
Total	**15**	**67**	**7**	**10,44%**

Table 5: Percentage of health education objectives in the physics and chemistry textbook, 3nd year of secondary school

Part	**Lesson**	Total objectives (1)	Total health education objectives (2)	Percentage of **(**1**)** to **(**2**)**
1	**1**	**4**	**0**	**0%**
	2	**5**	**0**	**0%**
	3	**6**	**1**	**16,66%**
	4	**5**	**0**	**0%**
	5	**3**	**0**	**0%**
	6	**2**	**0**	**0%**
	7	**3**	**3**	**100%**
2	**1**	**8**	**2**	**25%**
	2	**6**	**0**	**0%**
	3	**1**	**0**	**0%**
	4	**3**	**0**	**0%**
Total	**11**	**46**	**6**	**13,4%**

Table 6: Chemical and electrical safety in the home (French Ministry of Education, 2018)

Notions and contents	Knowledge and skills required Experimental activities in support of training
How can I safely use acidic or basic household products?	
Quantity of matter, relationship between mass and quantity of matter Solute and solvent Mass concentration C_m and molar concentration C of a solute in solution	Calculate a molar mass M. Know and use the relationship n = m/M. Define a solute, a solvent and a solution. Know and use the relationships n = C × V and m = Cm × V. Propose and/or implement a dissolution and dilution protocol to prepare a solution with a given molar or mass concentration of a molecular or ionic solute.
pH of an aqueous solution $[H3O+]=10^{-pH}$	Know and use the relationship $[H3O+] = 10^{-pH}$. Define the neutral, acidic or basic nature of an aqueous solution in terms of pH.
Measuring the pH of an aqueous solution Acid, base, acid/base pair, acid-base reaction Acidity and basicity scales, acidic, basic, neutral aqueous solution	*Propose and/or implement an experimental protocol for measuring the pH of an aqueous solution.* Define an acid and a base according to Brönsted. Write the equation of an acid/base reaction using acid/base pairs. Know the common names and formulas of the most common acids and bases: hydrochloric acid, ethanoic acid, sulfuric acid, soda, ammonia.
Autoprotolysis of water, ionic product of water, $[H3O^+]$ and $[HO^-]$ molar concentrations	Write down the equation for the autoprotolysis reaction of water. Use, without calculation, the expression for the ionic product of water to qualitatively relate the concentrations [H3O+] and [HO-].
Safety pictograms Chemical safety rules for acids and bases	*Propose and/or implement a protocol for classifying household products according to their acidity.* Know the meaning of safety pictograms. Apply safety rules relating to the use of concentrated acidic and basic solutions, and their mixing. Know what to do in the event of an acid or base splash. *In the context of waste management, implement a protocol for neutralizing an acid solution with a base solution.*

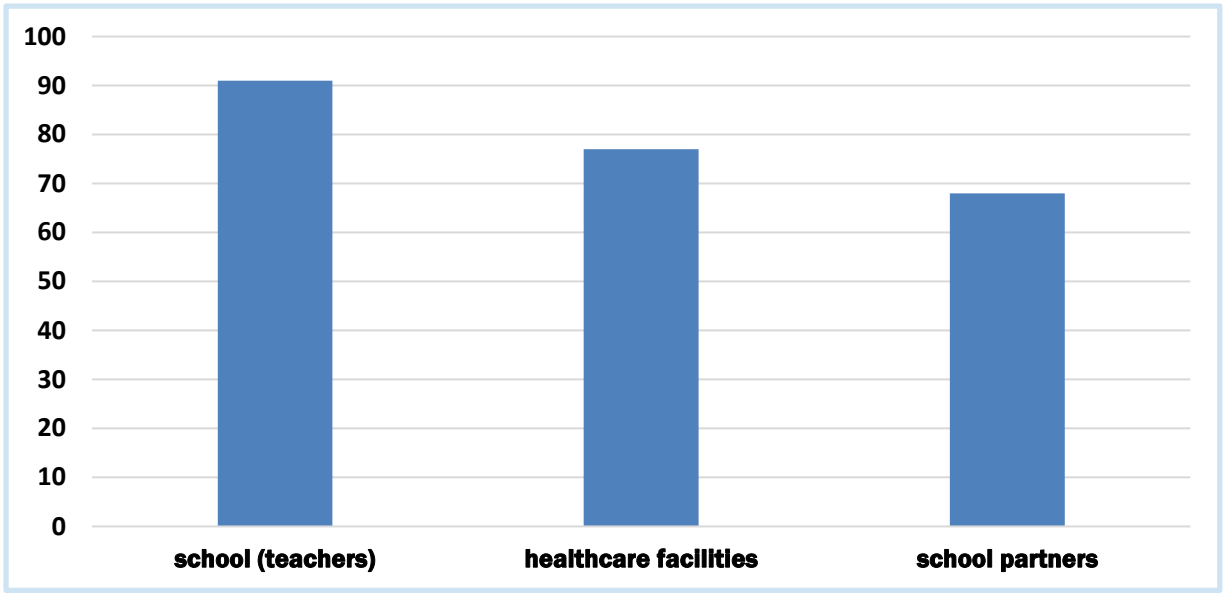

Figure 1: Health education stakeholders

4. Conclusions

Our research has shown that there is a lack of health education topics in physics and chemistry curricula. In this context, several countries have adopted health education as a subject to be taught independently. Indeed, those responsible for education and training in Morocco need to prioritize health education in their strategic plans, to enable learners to maintain the physical, mental and social capacities required for a healthy life.

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Conflicts of interest

The authors declare that there are no conflicts of interest.

Ethical approval

All ethical procedures were followed and our study was validated by a provincial ethics commission.

Reference

[1] H. Sevian et V. Talanquer, « Rethinking chemistry: a learning progression on chemical thinking », *Chem. Educ. Res. Pract.*, vol. 15, nº 1, p. 10-23, 2014, doi: 10.1039/C3RP00111C.

[2] A. E. J. Wals, « Shaping the education of tomorrow: 2012 full length report on the UN Decade of Education for Sustainable Development; 2012 ».

[3] A.-M. Summanen, J. Rautopuro, L. Kannas, et L. Paakkari, « Measuring Health Literacy in Basic Education in Finland: The Development of a Curriculum- and Performance-Based Measurement Instrument », *Int. J. Environ. Res. Public. Health*, vol. 19, nº 22, p. 15170, nov. 2022, doi: 10.3390/ijerph192215170.

[4] K. Yoshie, B. John, et M. Peter, *Caring and learning together: a cross-national study on the integration of early childhood care and education within education*. UNESCO, 2010.

[5] R. A. Hahn et B. I. Truman, « Education Improves Public Health and Promotes Health Equity », *Int. J. Health Serv. Plan. Adm. Eval.*, vol. 45, nº 4, p. 657-678, 2015, doi: 10.1177/0020731415585986.

[6] P. Barrett, A. Treves, T. Shmis, D. Ambasz, et M. Ustinova, *The Impact of School Infrastructure on Learning: A Synthesis of the Evidence*. Washington, DC: World Bank, 2019. doi: 10.1596/978-1-4648-1378-8.

[7] A. El Bakkali, « The Power of Distributed Leadership Styles in Education Practices: The New Challenges and

Perspectives of the Moroccan School », sept. 2022, doi: 10.5281/zenodo.3692413.

[8] H. Idrissi, L. C. Engel, et Y. Benabderrazik, « New visions for citizen formation: An analysis of citizenship education policy in Morocco », *Educ. Citizsh. Soc. Justice*, vol. 16, nº 1, p. 31-48, mars 2021, doi: 10.1177/1746197919886279.

[9] J.-W. Lin, M.-H. Yen, J. Liang, M.-H. Chiu, et C.-J. Guo, « Examining the Factors That Influence Students' Science Learning Processes and Their Learning Outcomes: 30 Years of Conceptual Change Research », *Eurasia J. Math. Sci. Technol. Educ.*, vol. 12, nº 9, p. 2617-2646, juill. 2016, doi: 10.12973/eurasia.2016.000600a.

[10] M. Heger, L. Vashold, A. Palacios, M. Alahmadi, et M. Acerbi, *Blue Skies, Blue Seas: Air Pollution, Marine Plastics, and Coastal Erosion in the Middle East and North Africa*. World Bank Publications, 2022.

[11] O. Sunkel, Vereinte Nationen, Instituto Latinoamericano y del Caribe de Planificación Económica y Social, et UNEP, Éd., *The environmental dimension in development planning. T. 1: Osvaldo Sunkel ... - 1990. - 302 S. - Enth. 9 Beitr. / [Sunkel, Osvaldo]*. in Libros de la CEPAL, no. 24. Santiago, Chile, 1990.

[12] K. Olson et C. Smollin, « Carbon monoxide poisoning (acute) », *BMJ Clin. Evid.*, vol. 2008, p. 2103, juill. 2008.

[13] P. Kumar *et al.*, « The nexus between air pollution, green infrastructure and human health », *Environ. Int.*, vol. 133, p. 105181, déc. 2019, doi: 10.1016/j.envint.2019.105181.

[14] Y. Bar-Cohen, « Biomimetics—using nature to inspire human innovation », *Bioinspir. Biomim.*, vol. 1, nº 1, p. P1, avr. 2006, doi: 10.1088/1748-3182/1/1/P01.

[15] Y. K. Dwivedi *et al.*, « Opinion Paper: "So what if ChatGPT wrote it?" Multidisciplinary perspectives on opportunities, challenges and implications of generative conversational AI for research, practice and policy », *Int. J. Inf. Manag.*, vol. 71, p. 102642, août 2023, doi: 10.1016/j.ijinfomgt.2023.102642.

[16] S. Guerriero et S. Guerriero, « Teachers' Pedagogical Knowledge and the Teaching Profession ».

[17] INSERM Collective Expertise Centre, *Health education for young people: Approaches and methods*. in INSERM Collective Expert Reports. Paris (FR): Institut national de la santé et de la recherche médicale, 2001. Consulté le: 20 septembre 2023. [En ligne]. Disponible sur:http://www.ncbi.nlm.nih.gov/books/NBK7118/

[18] M. R. Kibler et J.-C. Poizat, *La Physique pour la Santé : du diagnostic à la thérapie*. Institut de Physique Nucleaire de Lyon, 2003, p. 240. Consulté le: 20 septembre 2023. [En ligne]. Disponible sur: https://hal.science/hal-00001383