Activity: "Pharmaceuticals in the River?"

This activity entitled "Pharmaceuticals in the river?" has 4 phases. In the first phase, the case is presented to the students through a video of a scientist. He announces the alarming presence of pharmaceuticals in the Bodonal Stream (Community of Madrid) and asks the students to investigate and find out how and why it happened. In a second phase, the students are given a researcher's notebook (supplementary material 2) with questions to complete and a set of materials from which they must extract data and use them as evidence to argue their answers to be written in the notebook. The materials in different semiotic modalities are presented below. They can be seen in detail in supplementary material 2.

- A hydrographic map and a satellite map of the area. Students are asked to locate themselves on the map and identify the source of the river's pharmaceuticals.
- A bar chart of the pharmaceuticals most present in the Bodonal Stream and another of the pharmaceuticals most sold in the Community of Madrid. Both graphs are useful to know what is polluting the river and in what quantity, and to relate why the most-sold pharmaceuticals are not the most present in the river.
- An informative trifold leaflet on the pharmaceuticals present in the sample area and the most sold: what they are, what they are for, where they are consumed, etc. This material can be used to identify the pharmaceuticals prescribed to treat chronic diseases related to mental health.
- A video (**https://www.youtube.com/watch?v=Hi2ilunFSWc**, accessed on 1 October 2024) explaining what a wastewater treatment plant (WWTP) is and how it works.
- A scientific report detailing the findings on carbamazepine as an environmental pollutant: the side effects of carbamazepine, WWTP disposal capacity, etc.

After analyzing all the materials, students must individually answer the questions in their notebooks: "Based on what you have read and seen, what is polluting the river?" (Q1); "Based on what you have read and seen, where do the pharmaceuticals in the river come from?" (Q2); "What diseases do these pharmaceuticals treat?" (Q3); "If the pharmaceuticals most commonly found in the Bodonal stream are not the best-selling ones, how and why do they end up in such large quantities in the stream?" (Q4); "Is it harmful for pharmaceuticals to be in the river? Why?" (Q5); "Would it be better to take medication or not? Why?" (Q6); and "What solutions can you think of to prevent so many medicines from reaching the river?" (Q7). A reference answer for each of these questions is provided in supplementary material 1.

In a third phase of the activity, students must work in groups and solve the case again. They have to discuss their individual answers and write a single group answer to each question. Finally, in the fourth phase, a large group debriefing will take place in which students will be guided to the complete reference answer of the activity.

Q1: "Based on what you have read and seen, what is polluting the river?"	
LEVEL	DEFINITON
Null (1)	Does not know/no answer/not applicable.
Low (2)	The student mentions only things that are not pharmaceuticals (e.g., garbage, plastics, etc.).
Medium-low (3)	The student mentions that the river is contaminated with some pharmaceuticals.
Medium-high (4)	The student mentions all the pharmaceuticals in the river.
High (5)	The student lists all pharmaceuticals present in the river, highlighting carbamazepine. The student demonstrates proper use of graphs.
Q2: "Based on what you have read and seen, where do the pharmaceuticals in the river come from?"	
LEVEL	DEFINITION

Null (1)	The student indicates that the pharmaceuticals come from pharmacies and hospitals (any), from outside Madrid, or that people throw them in the river. The student does not use the map and the content is incorrect.
Low (2)	The student indicates that they come from the psychiatric hospital or Wyeth Farma (shown on the map). The student does not use the map and the content is wrong.
Medium-low (3)	The student indicates that the origin of the pharmaceuticals is for domestic consumption or only indicates that they come from the WWTP. The student does not use the map, although the content is correct, based on the report or the trifold leaflet or the WWTP video.
Medium-high (4)	The student indicates that the origin of the medicines is Tres Cantos, Soto de Viñuelas, from the Tres Cantos WWTP. The student makes correct use of the map, and the content is not erroneous but insufficient.
High (5)	The student shows that the origin of the medicines is domestic consumption, and indicates the geographical location (Tres Cantos, Soto de Viñuelas, Tres Cantos WWTP). The student makes good use of the map and the trifold leaflet, and the content is correct and complete.
Q3: "What diseases do these pharmaceuticals treat?"	
LEVEL	DEFINITION
Null (1)	Doesn't know / no answer / not applicable.
Low (2)	The student lists medications rather than diseases.
Medium-low (3)	The student indicates the pharmaceuticals present (or absent) in the stream by mixing information (in some cases indicating the diseases they treat and in others the type of drug being treated), or by indicating only the type of drug (e.g., antiepileptic drug).
Medium-high (4)	The student makes a verbatim copy of the information that appears on the information leaflet of the medicines present in the river (without mentioning the rest).
High (5)	Through his own speech and based on the information in the trifold leaflet, the student points out the illnesses that can be treated with the medicine found in the river.
Q4: "If the pharmaceuticals most commonly found in the Bodonal stream are not the best-selling ones, how and why do they end up in such large quantities in the stream?"	
LEVEL	DEFINITION
Null (1)	Doesn't know / no answer / not applicable.
Low (2)	The student answers with some data, but without establishing a valid relationship.
Medium-low (3)	The student only refers to the ineffectiveness of the wastewater treatment plant (WWTP) in eliminating pharmaceuticals. The student uses the report.
Medium-high (4)	The student adds to the above the relationship between the most and least sold pharmaceuticals and how they are disposed of at the WWTP. The student makes appropriate use of the report and graphs.
High (5)	The student also considers that the pharmaceuticals most present in the river are used for chronic treatments and therefore their discharge is constant. The student makes appropriate use of the report, graphs and even the trifold leaflet.
Q5: "Is it harmful for pharmaceuticals to be in the river? Why?"	
LEVEL	DEFINITION
Null (1)	Doesn't know / no answer / not applicable.
Low (2)	The student indicates that it is good, with or without justifying the answer with available data.
Medium-low (3)	The student states that it is harmful, without providing any data to support this, and without demonstrating an assimilation of the One Health concept.
Medium-high (4)	The student points out that it is harmful and justifies this with evidence but does not demonstrate any approach to One Health. The student makes appropriate use of the report.
High (5)	The student takes the position that it is harmful and justifies this with a statement that it is moving towards the One Health concept (contaminated water/environmental health, animal health and human health). The student makes appropriate use of the report.

Q6: “Would it be better to take medication or not? Why?”	
LEVEL	DEFINITION
Null (1)	Doesn't know / no answer / not applicable.
Low (2)	The student takes a position without justifying his answer.
Medium-low (3)	The student takes a position without properly justifying his answer.
Medium-high (4)	The student takes a stand and justifies its response by mentioning the benefits of pharmaceuticals or by starting to offer alternatives.
High (5)	The student positions and justifies his answer by mentioning the benefits of medicines or by starting to mention alternatives. The ideas of avoiding self-medication, the need for prescription and/or responsible use should be present.
Q7: “What solutions can you think of to prevent so many medicines from reaching the river?”	
SOL.	DEFINITION
A	Changes or improvements in the design of pharmaceuticals or WWTP.
B	Responsible consumption, not self-medicating or reducing the use of pharmaceuticals
C	Political or legislative measures.
D	Not content-related or generic to environmental protection.
E	No solutions are offered.

Categorization of the use of materials

Taxonomy of Barret (1968) for textual materials	
LEVEL OF COMPREHENSION	DEFINITION
1: Reading comprehension	Recognizing explicit information in text, identifying dates.
2: Reorganize information	Establish logical relationships between ideas, synthesize, classify.
3: Inferential or interpretive	Integrating new implicit meanings from the text.
4: Critical or evaluative judgment	Reflecting critically, comparing the ideas in the text based on personal experience or other external sources of authority.
5: Reading evaluation	Evaluating the language, the style of the text, and the sensations or effects of the text on the reader.

Taxonomy of Curcio (1989) for graphs	
LEVEL OF COMPREHENSION	DEFINITION
1: Read the data	No data interpretation; the answer may be a literal copy of the graph title or axis.
2: Reading between the data	How to interpret the data, how to make comparisons between the values.
3: Reading beyond the data	This requires inference and extrapolation of data, linking the interpretation of the graph to students’ prior knowledge or concepts present in the graph.
4: Reading behind the data	It involves a critical analysis of the graph and the quality of the data, linking the values in the graph to context.