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Photocomic Narratives as A Means to Communicate Scientific Information about Use, Treatment and Conservation of Water

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Abstract: In this research we propose that photocomics represent an opportunity to communicate scientific information to students in a reliable and economic way. We used these narratives to communicate information about efficient water management activities and also to publicize PUMAGUA, the Program of the Autonomous National University of Mexico (UNAM) in charge of water management at the University. Using the Retell, Identify, Remember and Contextualize information (RIRC) method (a method that uses memory tasks to assess learning) we tested the efficiency of this kind of illustrated narratives to communicate scientific information. We found statistical evidence that students acquired information regarding water use using this media and we also found statistical differences in performance between the participants of different schools at the main campus of UNAM.

Key words: narratives, photocomics, science communication, water conservation, water management

1. Introduction

While human population worldwide tripled in the last century, the use of water resources grew six-fold. Within the next fifty years, the world population will increase by another 40 to 50%. This increase, together with industrialization and urbanization, will result in a growing demand for water [1]. Strategies for efficient water management are urgently needed throughout the world, particularly in regions with high water stress. By 2025, 1.8 billion people will be living in countries or regions with severe water scarcity, and two-thirds of the world's population could be living under water stressed conditions [2]

In the case of Mexico, although it is ranked number 53 in the world in terms of water stress [3] most of its territory suffers from medium-high to very high stress.

In order to contribute to water conservation in Mexico, in 2008, the National University of Mexico (UNAM) launched the Program for Water Management, Use and Reuse (PUMAGUA) with three main objectives: (1) to reduce water consumption by 50%; (2) to improve the quality of drinking and treated wastewater according to the most strict water quality norms; (3) to promote participation of the entire population of the university in the efficient use of water. The Program started at the main campus in Mexico City and has progressively been implemented at other campuses of the UNAM.

To achieve the third objective of PUMAGUA, a communication/participation program was implemented, which includes innovative and participative activities to promote successful practices of water conservation, such as workshops, artistic contests, festivals, concerts, and print products, among them photocomic narratives.

Narratives are particularly important in Mexico, as they represent an informative vehicle for anyone who has left the classroom years ago and needs to be updated, as well as for teaching students in the classroom [4-8]. Narratives provide a precise tool with

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which to represent and transmit knowledge; they are an effective emotional detonator, a long term mnemonic structure, and an important reinforcement for learning [9] Stories enhance the process of communication and are fundamental both at the level of the community and of the individual[10]

The presentation of scientific information by means of short stories, novels, drama and comic strips should be considered as an important resource for the dissemination of knowledge, among the range of instruments at the disposal of science communicators and writers [11]. Comics are a popular art form and provide a potential medium for science education and communication [12]. Years of research in pedagogy have shown that text and illustrations work well together to improve instruction [13]. The advantage of using comic strips to communicate information is that they induce the use of several parts of the brain, allowing the reader to catch textual sequential information besides the visual holistic information [14]

Early studies have shown the effectiveness of comic strips to convey knowledge and practices related to particular scientific concepts [15-16]. They have been particularly helpful in health and science learning sectors. In Egypt, for instance, the World Health Organization used them to disseminate knowledge about lymphatic filiasis (a disease that can lead to elephantiasis) and to reduce stigma towards people who had developed elephantiasis [17]. In China, they were successfully used, together with a cartoon video, to explain the transmission of schistosomiasis, as well as to discourage children from playing in known infected waters [18]. In the United, comics conveyed information regarding health risks from contact with pesticides, as well as proper use and storage of these products [19].

With regards to science learning, Hosler and Boomer [13] proved the effectiveness of a comic book to disseminate knowledge and positive attitudes towards Biology. In this study a questionnaire was applied before and after exposure to the comic book in the classroom. These authors found that an increase in knowledge was particularly high in students who had shown the lowest performance in the class before exposure to the comic book.

In Mexico, comic strips (and photocomics) are a cultural narrative medium that is deeply established in national culture, as it is the principal access to reading for millions of inhabitants. This is the case of more than one third of Mexicans between 12 and 22 years of age [20]. Photocomics are a particular kind of comic strip where the images are photos rather than drawings; they are also very popular among the population.

Although Mexico is a country in which the reading rate is low, if we take into account the total population we find that the absolute number of readers is considerable. By and large, what the Mexican public reads are superficial and disposable texts [21]. Evidence of this can be found in the high press runs of magazines covering entertainment gossip, fashion, and comic strips with stereotyped storylines (sex, crime or pseudo westerns). Nowadays, comic strips are one of the preferred media and the principal access to reading for millions of Mexicans. In the last decade they represented around 33.5% of total publications in this country [20].

The fact that comic strips (photocomics) already have a great appeal among a broad sector of the population makes them a very attractive medium to reach numerous segments of society. If we are capable of designing a tool, suitable for transmitting scientific information about water use, treatment and conservation, that achieves a positive impact and stimulates individuals to avoid waste, we will contribute significantly to social well-being.

In order to measure the effects of the photocomic in the retention of scientific information, the RIRC method [11] was employed to evaluate the comprehension and retention of scientific knowledge. The RIRC method explores the effectiveness of a narrative (and other formats) for communicating scientific information using four independent memory

tasks to assess learning. This method assesses an individual's ability to retell, identify, remember and contextualize scientific information presented to them in narrative form. The input consists of a qualitative complex stimulus (a story narrative or another text format) and the outcome is measured using questionnaires.

2. Material and Methods

The basis for the development toward energy saving under economic points of view are the classification and the comparison of the energy demand of the agricultural operation and the single aggregates with the certain specific operating reference values of the plant.To establish an exact and differentiated database to the analysis of the single production processes energy consumption values dependent on procedure of single consumers (devices and machines which are fused in the electric distribution separately, e.g., vacuum pump and cooling aggregate in dairy farms)and consumer groups(summary of several single consumption components to a consumption group, e.g., airing control, engines for regulating flaps, fans in the consumption range ventilation or all luminous units of the stable in the consumption area lighting) are evaluated and measured.

We adapted a script (that had originally been written for a short film by Biology undergraduate students of the UNAM) to a photocomic (Appendix I). The plot is about a girl that bumps into her friend and they decide to go together to print her thesis n on the university campus. First they go to the toilet, where her memory stick (USB) with the dissertation falls into the toilet. The search for the memory stick serves as an excuse to show the water management system at the campus, as well as PUMAGUA specific actions to improve water use.

Copies of the photocomic were presented to seven classes of undergraduate students, each belonging to a different school at the UNAM. Students read the narrative and subsequently answered a questionnaire with ten questions regarding technical information about the water management system and PUMAGUA's actions (Appendix II). Using the RIRC method, questions were designed to measure memory tasks regarding the information presented in the photocomic: four questions concerning identification, three regarding recall, and one to test the ability to contextualize the information. In order to identify the issues that were known beforehand and therefore to avoid overestimating the effect of the narrative on individuals' knowledge of the subject, the five students randomly selected in each group (control group) were asked to answer the questionnaire without first reading the photocomic.

Responses to questions 1 to 9 (identifying and remembering) were marked in a binary way (correct or incorrect), while answers to question 10 (contextualize), were analyzed using two methods. First, answers were coded using the following categories: (a) answers referred to the information contained in the narrative and reflected that the information was well understood, (b) answers were ambiguous (not clear if the information was correctly understood), (c) answers were imprecise or unrelated to the photocomic, (d) answers were wrong, or (e) the question was not answered.

The second method involved the following: the words included in the answer to question 10 were analyzed to determine if they were those used originally in the narrative. Also synonyms were extracted, as well as other words that did not appear in the photocomic, but belong to water management jargon.

The following table (Table 1) includes the list of themes that we wanted to convey to the students (active principles) through the photocomic, as well as the specific question of the questionnaire that inquires about each theme.

3. Results and Discussion

The students that voluntarily collaborated in this

study belonged to the schools of Accounting, Chemistry, Earth Sciences, Engineering, Political Sciences, Philosophy, and Psychology of the UNAM. A total of 312 undergraduate students participated, 172 females and 140 males ranging from 18 to 23 years of age. From this sample 277 read the photocomic and answered the questionnaire and 35 only answered the questionnaire (control group) (Table 2).

Table 1 Themes included in the photocomic "The Mystery of the USB" and number of question of the questionnaire addressing each theme.

Theme	Description	Question addressing each theme
Water management system	Extraction, distribution, consumption, treatment, and reuse of water	1
Safe drinking water	Disinfection system and consumption in water fountains	3,10
Safely treated wastewater	Treatment plant with innovative process and safe use of treated wastewater to irrigate gardens	5,10
Water conservation actions	Toilet retrofit, reporting leaks, hygiene actions	7,8
PUMAGUA actions	Toilet retrofit, water disinfection system	6

Table 2 Number of students from each school that read the photocomic.

School	Number of participants
Accounting	50
Chemistry	20
Earth Sciences	51
Engineering	34
Political Sciences	17
Philosophy	55
Psychology	50
Total	277

Two different statistical analyses were conducted: T-tests were calculated to assess the effectiveness of the photocomic to convey information about water management and ANOVAs were calculated to assess the difference in knowledge acquisition between participants from different schools. When statistical differences were found post hoc, comparisons using Sceffé's method for a single-step multiple comparison were performed in order to determine which schools were responsible of the differences.

Table 3 and Fig. 1 present a comparison of answers to each question between participants that read the photocomic and those that only answered the questionnaire. There were significant differences in both the mean of correct answers to each question and the overall score, with participants who read the photocomic scoring higher score than those who did not.

Table 3 Comparison of correct answers between participants who read the photocomic and those who did not.

	Reading the photocomic (N = 277)	Not reading the photocomic (N = 35)	t	p
Means (Standard deviations)				
Question 1	0.80 (0.397)	0.03 (0.164)	22.112	.000***
Question 2	0.69 (0.462)	0.16 (0.136)	7.939	.000***
Question 3	0.91 (0.286)	0.57 (0.502)	4.073	.000***
Question 4	0.44 (0.497)	0.08 (0.227)	6.634	.000***
Question 5	0.92 (0.227)	0.51 (0.507)	4.756	.000***
Question 6	0.95 (0.221)	0.57 (0.502)	4.564	.000***
Question 7	0.95 (0.214)	0.35 (0.484)	7.462	.000***
Question 8	0.22 (0.418)	0.00 (0.000)	9.485	.001***
Question 9	0.88 (0.331)	0.54 (0.505)	3.928	.000***
Question 10	0.66 (0.473)	0.22 (0.417)	6.072	.000***
Mean of overall score	0.74 (0.167)	0.30 (0.123)	19.617	.000***

*p ≤ .05, **p ≤ .01, ***p ≤ .001

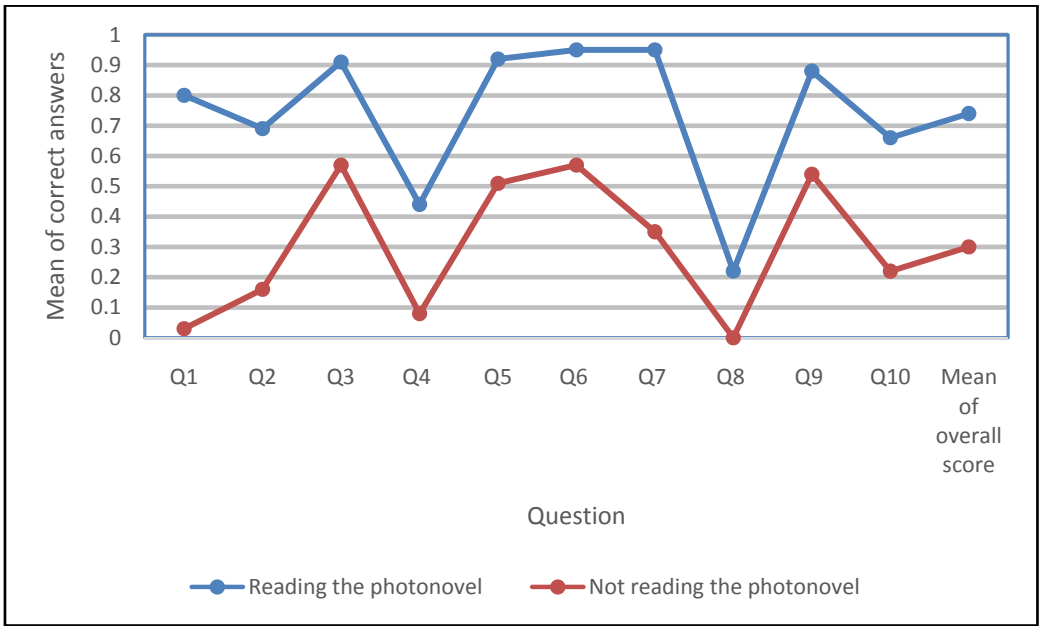

Fig. 1 Differences in correct answers and overall score between participants that read the photocomic and those who did not.

The regular cleaning, servicing and inspection of the ventilation system should take place at least semi-annual. To this the temperature sensors must be calibrated if necessary and all regulating systems should be optimally adjusted. By regular cleaning all supply and exhaust air ducts, ventilating fans and airing flaps the unnecessary pressure losses to be compensated by the ventilation system which lead to an increase of the power consumption can be avoided. The examination and if necessary the adaptation of the climate rated values to seasonal aerial change variations and the growth curve of the animals also belongs to a regular servicing. Thus an efficient operation of the ventilation system can be ensured.

With regard to the difference in knowledge acquisition between participants from several schools of the UNAM (Fig. 2), ANOVAs were calculated for each of the ten questions and for the overall score. By conducting Scheffe's post hoc method, significant differences were found in four questions and the overall score, as follows:

(1) Question 2. [F: (6/305) = 7.26, p=.000***], between the groups of Philosophy (= 0.85), Earth Sciences (= 0.82), Accounting (= 0.48), and Political Sciences (= 0.46).

(2) Question 4. [F: (6/305) = 4.33, p = .000***]: between the groups of Philosophy (= 0.60), Chemistry (= 0.70), and Psychology (= 0.27).

(3) Question 8: [F: (6/305) = 277.455, p = .000***]: between the groups of Philosophy (= 0.50), Accounting (= 0.40), Engineering (= 0.38), Earth Sciences (= 0.37), Political Sciences (= 0.29), and Chemistry (= 0.30).

(4) Question 10: [F: (6/305) = 249.619, p = .050*]: between the groups of Philosophy (= 0.84), and Accounting (= 0.56). Overall score [F: (6/305) = 7.26, p = .000***]: between the groups of Philosophy (= 0.84), Earth Sciences (= 0.70), Accounting (= 0.71), and Political Sciences (= 0.67).

Question 10 was answered by over 90% of respondents. To the question "Which aspects should you monitor in order to decrease the incidence of these diseases?" almost half of the answers were classified as option (a), i.e., "clear", which revealed understanding of the information contained in the narrative (Fig. 3). Examples of these were: "The disinfection system to see if it was working properly", "I would check if there is no risk from watering gardens with treated waste

water and that the treatment plant is working properly", or "That the irrigation water is not used for drinking". However, there were many cases where there was a high number of imprecise answers or the technical information was only slightly related to the comic. For instance some responded with short phrases such as "Water quality", "Purification", or "That filters are O.K.".

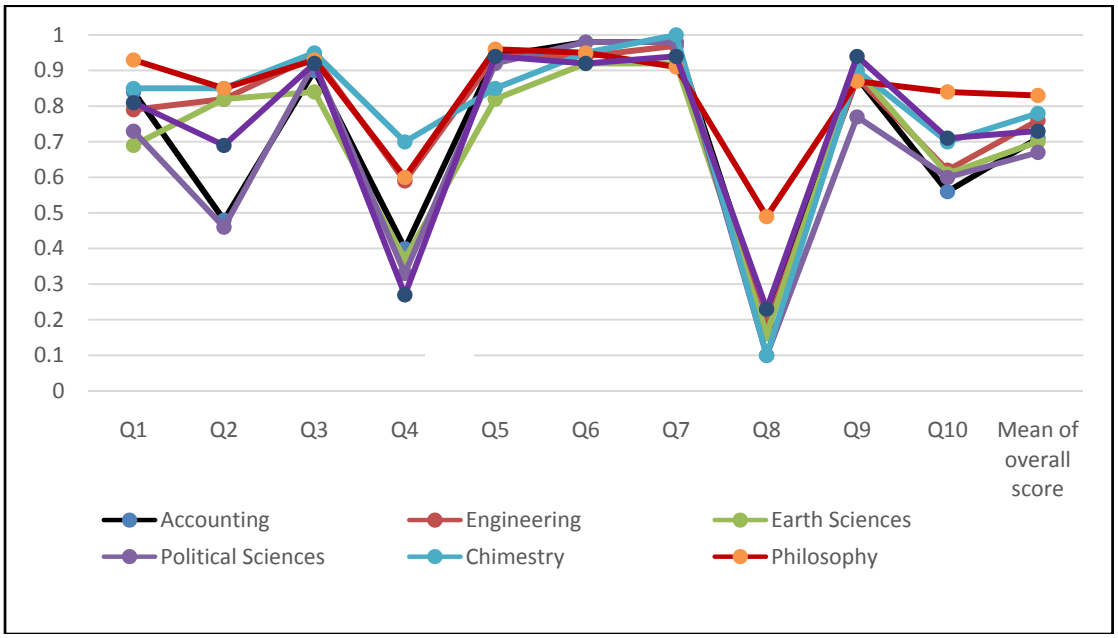

Fig. 2 Means of correct answers according to participants' schools.

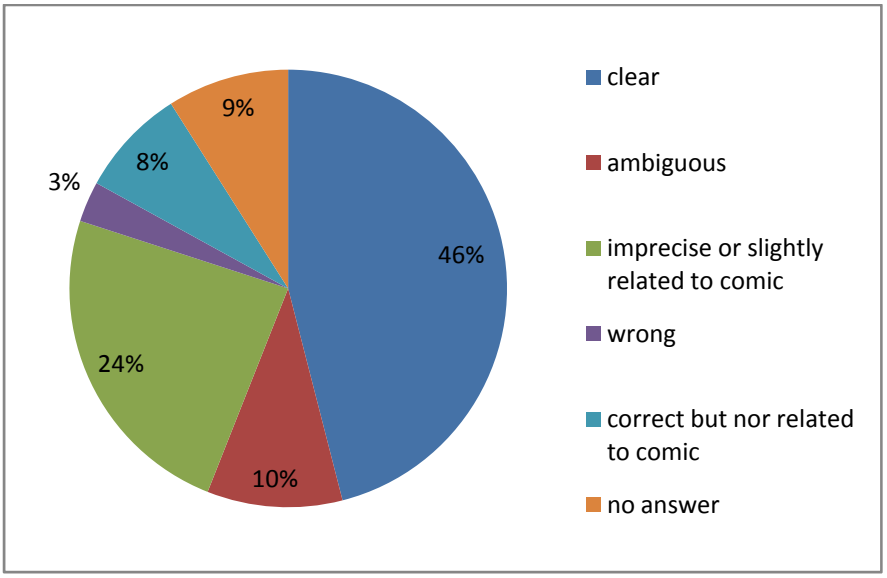

Fig. 3 Percentage of types of answers to contextualize question 10.

In 10% of responses, the answers were evaluated as "ambiguous", because apparently there is some confusion between the wastewater treatment plant used to produce water for irrigation and the disinfection system that provides drinking water. For instance in the answer "the process of the disinfection system, the filters, that the system is working properly" it seems as if the filters belong to the disinfection system while the photocomic mentions them as part of the wastewater treatment plant.

Eight percent of the answers were correct but the information did not come from the photocomic ("That the water tanks are clean", "Those students have good hygiene practices", "To fire the people in charge of the water system because they clearly do not care"). Less than 5% were wrong, like the following: "I would monitor the water treatment plant of the ultrafiltration membranes coming from the three wells". The respondent confused drinking water coming from the wells with wastewater treated with ultrafiltration membranes in the treatment plant. Other respondents confused the information that was used only as part of the literary plot, i.e., dropping the USB containing the thesis into the toilet.

Finally, it is worth mentioning that some answers were considered incorrect not because the information in the narrative was misunderstood but because it was not included in the photocomic. For instance: "I would make sure that water is not used to drink but instead that it is used in laboratories, toilets and irrigation". This is incorrect on two levels: first, because water that comes in contact with human skin, such as water used in laboratories, toilets and for watering purposes, must be free of pathogens. In addition, as mentioned beforehand, this information was not provided by the narrative.

When comparing answers to question 10 among participants of different schools, Philosophy had the highest percentage of clear answers, followed by Earth Sciences and Engineering, while Political Sciences performed the worst, and also had the highest number of ambiguous answers (Fig. 4).

Finally, the analysis of words most frequently used to answer question 10 showed that the ones best retained from the photocomic where water fountains, treatment plants, filters, treatment and disinfection system (Fig.5). As presented in Table 1, question 10 addressed two themes: safe drinking water and safe treated wastewater. Therefore, the words most frequently used corresponded to both subjects. In the case of safe drinking water, both the system that makes it safe (disinfection system) and the consumption point (water fountains) were pointed out, while in the case of safe treated wastewater, the system was repeatedly mentioned (treatment plant, filters, treatment), but the point of use (gardens) was scarcely cited. This is probably due to the fact that water fountains appeared at the beginning of the narrative, while gardens appeared in the last part of it. This matches with Negrete's observation that the closer the scientific information comes to the important moments in the narration (e.g., revelations, peripetia, anagnorisis, outcome, central functions, etc.), and the higher in hierarchy with respect to the plot, the more likely it is to succeed in being communicated and recalled [9].

Participants that read the narrative had a higher performance in all the tasks of the questionnaire than those that did not read it, regardless of the kind of questions (identify, remember, recall or contextualize). These results suggest that the photocomic generated in this research was effective in communicating technical information about water use.

4. Future Work and Research

Given the constraints of photocomics in terms of text extension and use of technical jargon, an important challenge for future work is to create one narrative that takes into account concepts found in this study that are either ignored or misunderstood by the public (e.g. differences between waste water and drinking water treatment systems, quality requirements for different uses of water). Given that water management in Mexico City is a subject of public concern, people have preconceived ideas about it, some of them incorrect. This can prove challenging because it is often more difficult to replace people's wrong ideas with right concepts than to convey information to a non-misinformed population.

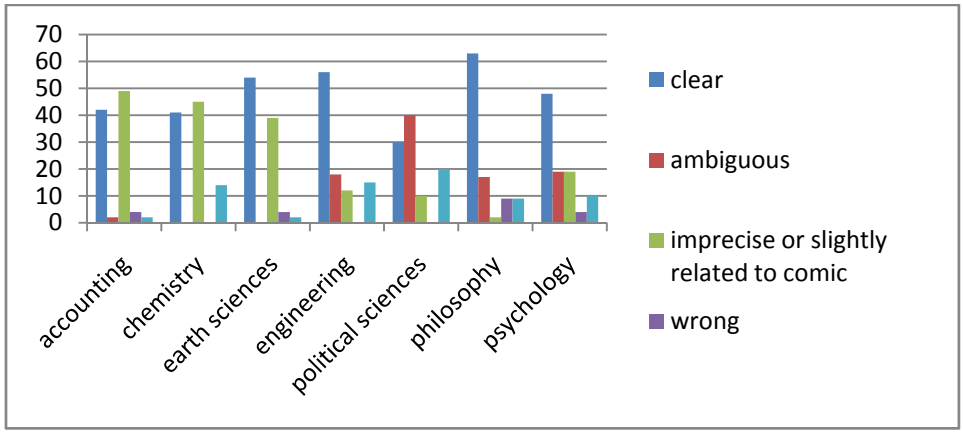

Fig. 4 Comparison between schools of types of answers to question 10.

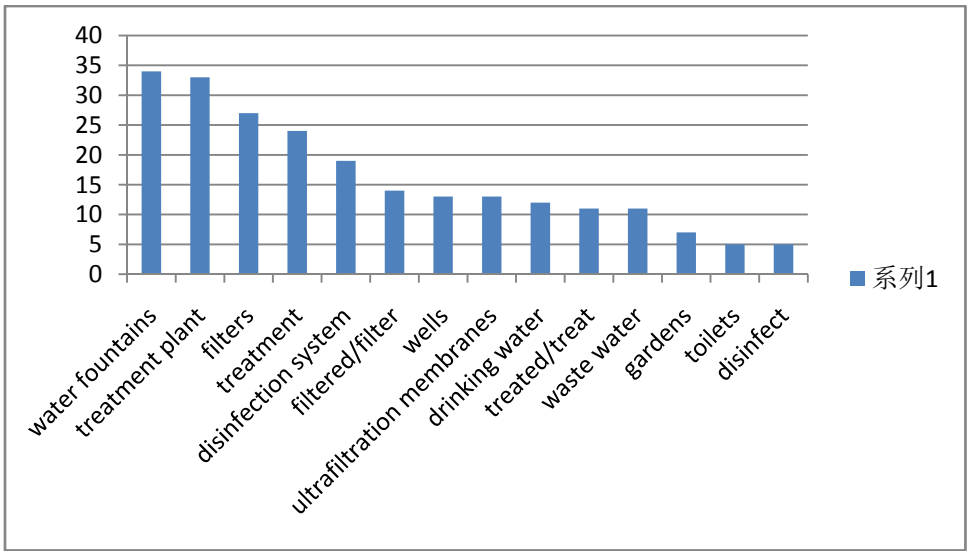

Fig. 5 Frequency of technical words most used in answers to question 10.

In a future study it would be desirable to evaluate if this knowledge persists over time and also to compare effectiveness and memorability between this photocomic and a non-narrative means, such as textbooks, technical reports, etc. According to Negrete (2009) narratives are equally efficient as non-narrative means in conveying scientific information, but are more memorable. In said study, the narratives used as stimulus were short stories (op cit). It is likely that photocomics are even more memorable because information provided by text is reinforced by images. As previous studies have asserted, words associated with imagery are learned more easily than those without [22].

When comparing knowledge acquisition between participants of different schools of the UNAM, a difference was detected only between Political Sciences and Philosophy. This may be explained by the fact that students of the latter are more used to reading narratives than those of political sciences.

It would be desirable to create more photocomics (1) to further explore the differences in learning processes between the various schools at the main university campus and (2) to reach other publics at the UNAM that need to be conscious of water conservation practices, such as gardeners, janitors and staff in laboratories. For the latter, a study of these audiences' narrative preferences should be carried out; it is foreseeable that the components of the narrative (the characters, plot, structure and language depicted in

such narratives) should be modified to successfully reach such groups.

5. Conclusion

The findings of this research as a whole suggest that photocomics are an effective means to communicate scientific information to the public with socially worthwhile messages. In this research we propose that popular photocomics can, for certain student audiences, be used as a tool to communicate scientific information in an understandable, memorable and enjoyable way. In the case of Mexico, they represent a unique opportunity to communicate scientific information about natural resources conservation to a large sector of the university population, often very difficult to reach through other means.

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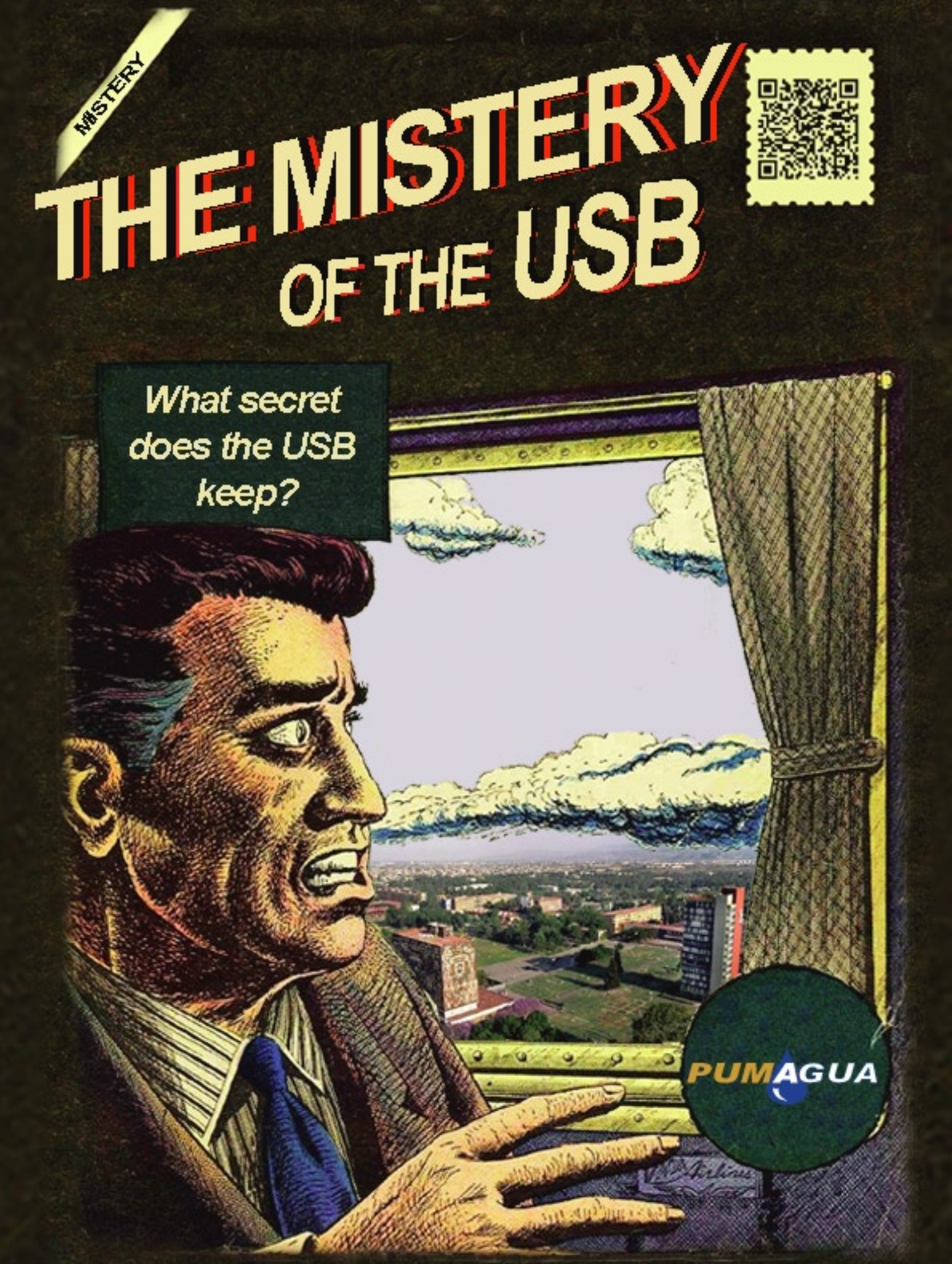
MISTERY

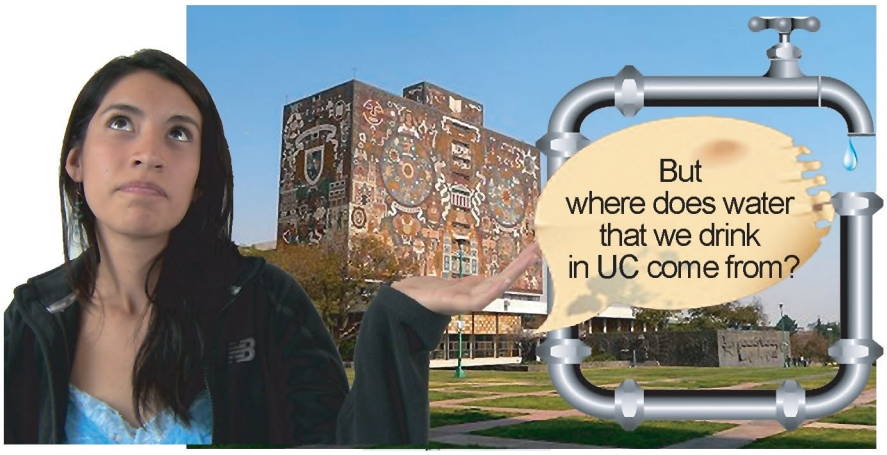
THE MISTERY OF THE USB



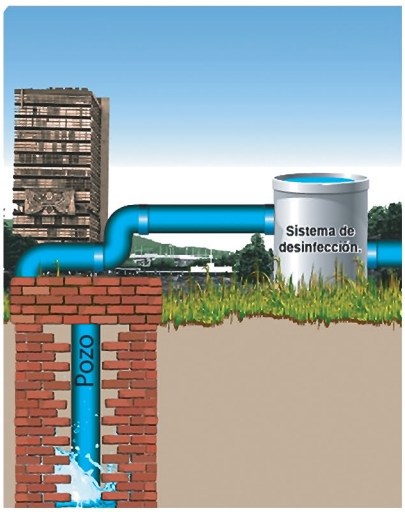
Any given day at the U.C.

Hi!
Can you come with me to the water fountain?

I've heard that the Direction of Works has installed a new disinfection system..

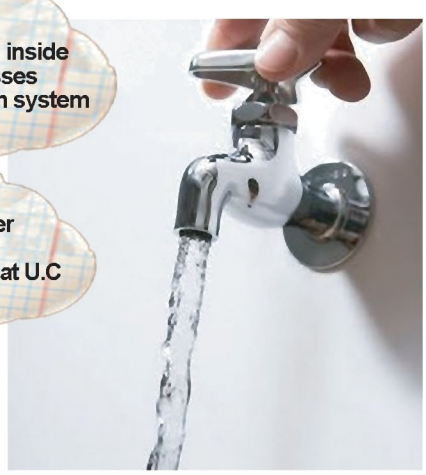


But where does water that we drink in UC come from?



It comes from 3 wells inside the campus. It passes through the disinfection system

and clean water comes out from every faucet at U.C



Mariana puts the USB in the pocket of her sweatshirt...

They both go to the nearest bathroom

Inside, there is a janitor

She opens the door and finds new automatic toilets. She reads a sign that says:

PUMAGUA
Agua saludable, acción de todos

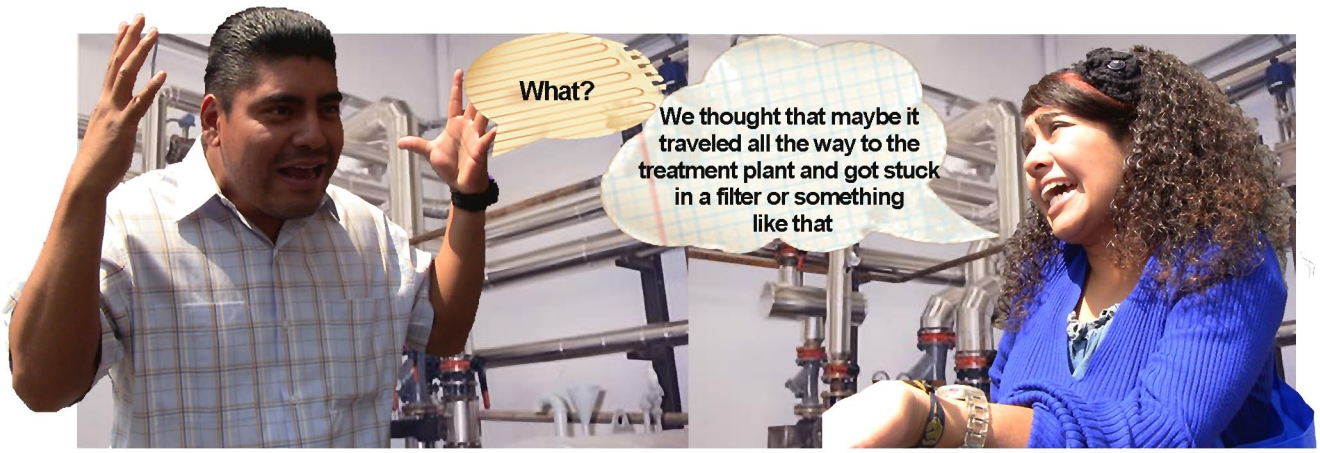
Este escusado sólo gasta 6 litros por descarga. Mantenlo limpio. Avisa al jefe de servicios si encuentras alguna falla.

The USB falls out of the pocket into the toilet, which is automatically activated and the USB goes down the drain. Mariana runs out of the toilet.

Diana and Mariana talk to a worker of the t reatment plant

As the worker is speaking,
Mariana approaches to Diana and whispers:

Las dos lo miran angustiadas porque lo que les urge es encontrar la USB...



Diana and the worker start to argue

Mariana's mobile phone rings.
When she sees it's her mother, she answers

PUMAGUA

www.pumagua.unam.mx