RESEARCH ARTICLE

Systemic Curriculum for Teaching Water Sustainability in the Colombian Amazon

Currículo sistémico para la enseñanza de la sostenibilidad del agua de la Amazonia colombiana

Currículo sistêmico para o ensino da sustentabilidade hídrica na Amazônia colombiana

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ABSTRACT

The water problem in the Colombian Amazon is rooted in deforestation, water wastage, water pollution and the absence of education aimed at the protection of water systems. In this context, the objective of this research is to propose a systemic curriculum for the teaching of water sustainability based on the conceptions of middle school teachers of the Institución Educativa Agroecológico Amazónico (IEAA) of El Paujil, Caquetá. With emphasis on the Action Research method, an interview validated by four experts with doctoral training was applied. The information was analyzed through grounded theory. The result of the research is a systemic curricular structure based on lesson plans, contents, didactic strategies, research processes, interdisciplinary work and evaluation processes.

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RESUMEN

The water problem in the Colombian Amazon is rooted in deforestation, water wastage, water pollution and the absence of education aimed at the protection of water systems. In this context, the objective of the research is to propose a systemic curriculum for the teaching of water sustainability based on the conceptions of middle school teachers of the Amazonian Agroecological Educational Institution (IEAA) of El Paujil Caquetá. With emphasis on the action research method, an interview validated by four experts with doctoral training was applied. The information was analyzed through grounded theory. The result of the research is a systemic curricular structure based on lesson plans, contents, didactic strategies, research processes, interdisciplinary work and evaluation processes.

RESUMO

O problema hídrico da Amazônia colombiana reside no desmatamento, no desperdício de água, na poluição da água e na ausência de educação destinada a proteger os sistemas hídricos. Nesse contexto, o objetivo da pesquisa é propor um currículo sistêmico para o ensino da sustentabilidade hídrica a partir das concepções de professores do ensino médio da Instituição de Ensino Agroecológico Amazônico (IEAA) de El Paujil, Caquetá. Com ênfase no método de pesquisa-ação, foi aplicada entrevista validada por quatro especialistas com formação doutoral. As informações foram analisadas por meio da teoria fundamentada. O resultado da pesquisa é uma estrutura curricular sistêmica apoiada em planos de aula, conteúdos, estratégias de ensino, processos de pesquisa, trabalhos interdisciplinares e processos de avaliação.

Introduction

The survival of humanity and all ecosystems on the planet are proportional to the preservation of water (Xiong *et al*., 2016; Da Silva *et al.*, 2019); even so, water stress is gradually increasing due to global population growth (Meireles *et al.*, 2018; Chandra *et al*., 2018). Even in the Colombian Amazon where rainfall and water sources abound, access to clean water is a privilege that is often hindered by waste and pollution generated by the region's inhabitants (Zhan *et al*., 2018; Santos *et al.*, 2019). In line with the above, 40.5% of middle school students of the Institución Educativa Agroecológico Amazónico (IEAA) of El Paujil Caquetá, state that they sometimes make inadequate use of water, despite the fact that 75.3% of these students consider that economizing this resource is very important to preserve life (Olmos-Rojas *et al*., 2021).

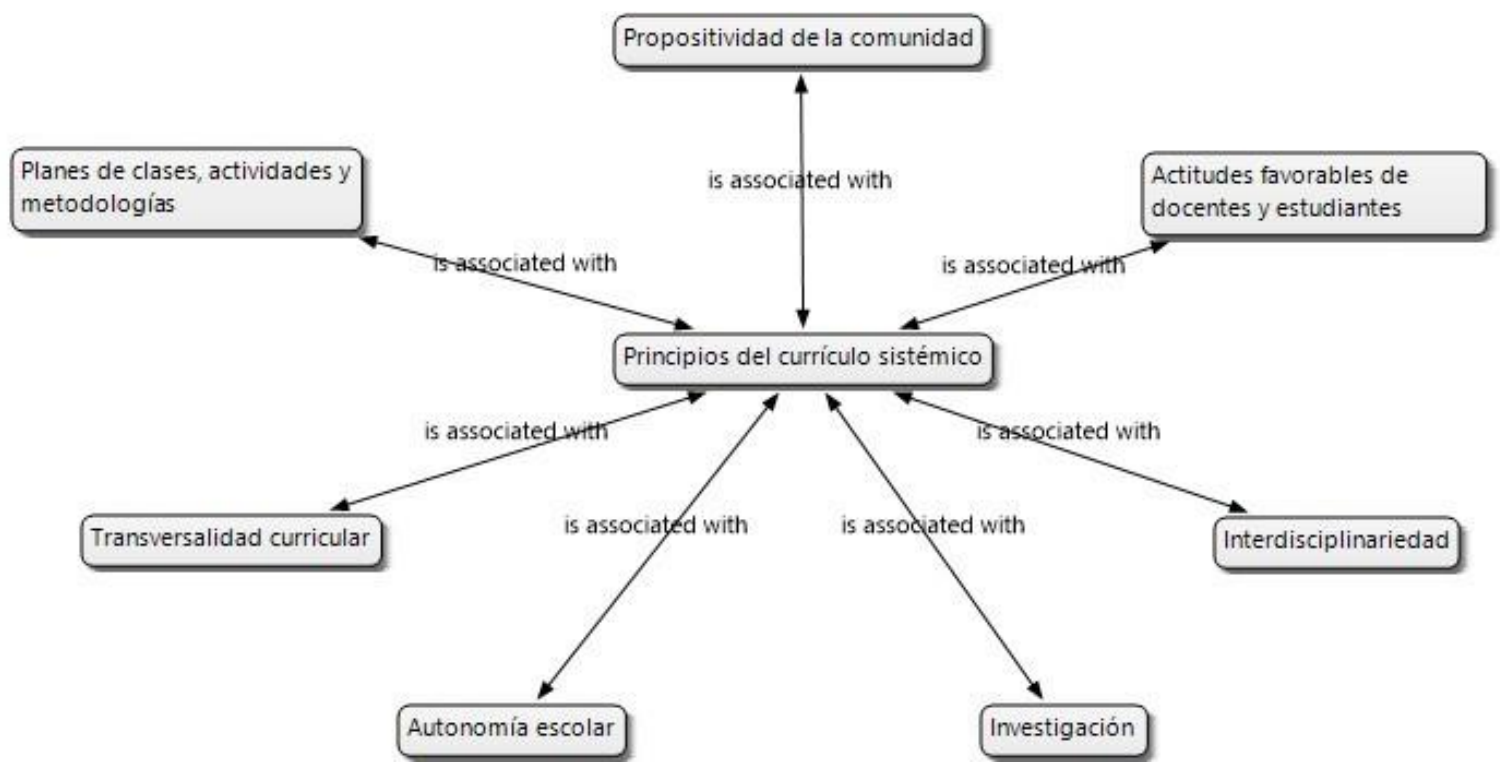
In addition to the above, 93% of the water sources supplying the municipalities of Caquetá are contaminated with solid and liquid waste (Gobernación del Caquetá, 2020); this situation is the cause of diarrheal diseases (Corporación para el Desarrollo Sostenible del Sur de la Amazonia, 2020); this situation is the cause of diarrheal diseases (Corporación para el Desarrollo Sostenible del Sur de la Amazonia, 2020).
-Corpoamazonia, 2009), the effect of which, as reported by the hospital of El Paujil, is evidenced by the death of infants under 5 years of age in that municipality (Alcaldía de El Paujil, 2020).

On the other hand, increasing deforestation in the Colombian Amazon alters the water balance (Instituto de Hidrología, Meteorología y Estudios Ambientales-IDEAM, 2019; Weng *et al*., 2019), affects water quality (Wu *et al.*, 2021) and reduces the flow of the sources that provide the vital liquid to the inhabitants (Corpoamazonia, 2009; Gobernación del Caquetá, 2020). As a result, in the territory of Caquetá there is a decrease in the water flows that supply municipal aqueducts (Gobernación del Caquetá, 2020).
In this environment, the research aims to structure a systemic curriculum for teaching water sustainability from the conceptions of IEAA middle school teachers, in order to promote habits of measured water use in students (Marinho *et al.*, 2014; Bagoly-Simó *et al.,* 2018), and thus, preserve the ecosystems that ensure sustainable limits of life on earth (García and Martínez*,* 2010).

However, the term curriculum was first used at the University of Glasgow in 1963, and was defined as an ordered structure of academic courses to be taught and learned (Kemmis, 1993). From Lundgren's (1992) conception, the curriculum is a set of contents transmitted through education. According to De Zubiría (1994), the curriculum includes: purposes, contents, sequencing, methods, didactic resources and evaluation.

In the present research, the systemic curriculum for water sustainability is shaped by the following principles (see Figure 1): a) the self-creative propositivity of teachers (Luhmann, 2007); b) school autonomy to seek solutions to the water crisis caused by the waste and pollution of this natural element (Ortega *et al.*, 2016; Amahmid *et al.*, 2018; Santos *et al.,* 2019); c) the social critical environmental current that articulates theory and action to transform social dynamics (Sauvé, 2005); d) the emancipatory interest, which is characterized by the transformation of the forms of social life (Habermas, 1982), and e) the cognitive interstructurative relationship, necessary to establish a dialogical relationship between students and teachers regarding water sustainability (Benninghaus *et al.,* 2018).

Figure 1. Principles of the systemic curriculum for water sustainability.



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It is considered that conceptions arise in the social sphere and develop in people's interactions (Remesal, 2011); they are cognitive in nature (Moreno and Azcárate, 2003), and have an impact on the mental constructs of individuals (Pozo *et al.*, 2006). From that logic, modifying the attitudes of human beings implies transforming their conceptions (Hidalgo and Murillo, 2017). In line with the foregoing, changing conceptions is a prior step

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to transform practices (Murillo *et al.*, 2014). In the educational environment, the conceptions of teachers are influenced by the social reality of the context (Van den Berg, 2002).

According to the above, the research is carried out in the IEAA, which is composed of three educational centers located in the Colombian Amazon, department of Caquetá, municipality of El Paujil. The IEAA has 1050 students (Sistema Integrado de Matrícula-SIMAT, 2022), a staff of 51 teachers, 12 administrative staff and 3 directors in 2022.

Materials and Methods

Based on the qualitative approach and the action research methodology, a semi-structured interview was conducted with 13 teachers who guide the middle level areas of the IEAA. It should be noted that the teachers authorized the interview by signing an informed consent form; however, the names of the teachers are not mentioned in the research in order to preserve the anonymity of the research subjects (Table 1).

Table 1. *Level of training and area of training of the teachers interviewed.*

Código	Título de pregrado	Título de posgrado	Área
P1	Ingeniero de Sistemas	Magíster en Educación	Estadística
P2	Licenciado en Bioquímica	Especialista en Pedagogía	Ciencias Naturales
P3	Licenciado en Sociales	Magíster en Educación	Filosofía
P4	Licenciada en Inglés e Ingeniera de Sistemas	Magíster en Informática	Inglés
P5	Licenciada en Matemática/Física	Magíster en Ciencias Físicas	Matemáticas
P6	Licenciado Lengua Castellana	Magíster en Educación	Lenguaje
P7	Licenciado en Inglés	Magíster en recursos digitales	Inglés
P8	Licenciada en Lengua Castellana	Especialista en Pedagogía	Ética
P9	Licenciado en Educación Física	Especialista en Lúdica	Educación Física
P10	Licenciado en Matemática/Física		Física
P11	Licenciada en Artística	Especialista en Pedagogía	Artística
P12	Licenciado en Pedagogía		Sociales
P13	Licenciado en Básica	Especialista en educación ambiental	Agroecología

On the other hand, the interview questionnaire was subjected to validation by four experts with doctoral training (Table 2).

Table 2. Information from the experts who validated the interview questionnaire

No.	Título del doctorado	Nacionalidad	Vinculación
1	Doctor en Educación, Post doctor en Ciencias Sociales	Colombiano	Universidad del Quindío
2	Doctora en Ciencias del Medio Ambiente	Mexicana	Universidad Veracruzana
3	Doctor en Agronomía	Española	Universidad de Valencia
4	Doctora en Educación	Colombiana	Universidad del Quindío

The information provided by the interviewees was analyzed through grounded theory; in this sense, both the structure of the questionnaire applied to the teachers and the structure of the presentation of the results is based on categories, subcategories, codes and units of information (Table 3):

Table 3. Categories, codes and subcategories

Categoría	Código de la subcategoría	Subcategoría
A. Concepciones de los profesores sobre la enseñanza de la	A1	Problemática hídrica de la Amazonia Colombiana.
	A2	Plan de clase.
B. Concepciones de los profesores sobre qué enseñar y cómo enseñar para promover la sostenibilidad del agua.	B1	Contenidos.
	B2	Aportes de los estudiantes
	B3	Estrategias didácticas.
	B4	Investigación.
	B5	Actividades a implementar.
	B6	Interdisciplinariedad.
	B7	Evaluación.

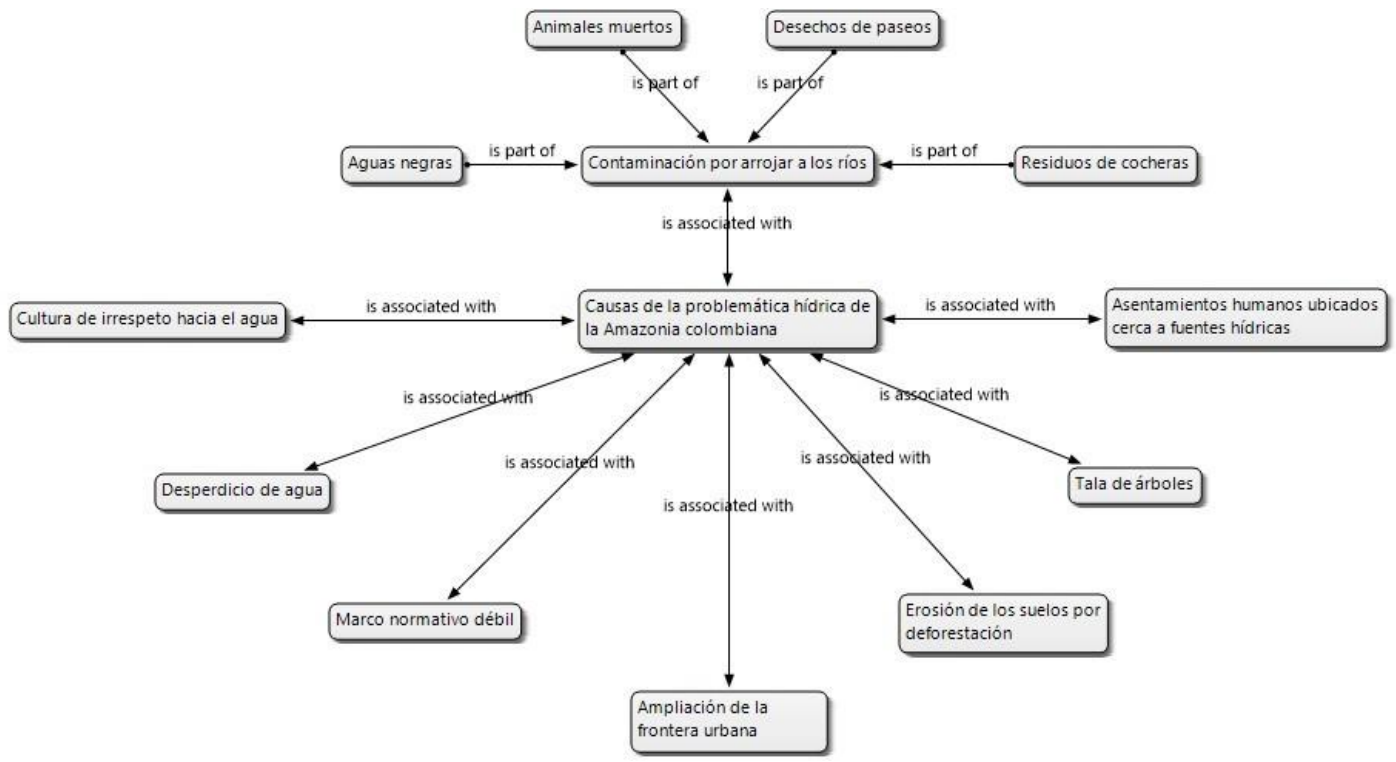
According to the above, the opinion of the interviewees is transcribed in quotation marks and sometimes in blocks when the text is longer than 40 words; the quotes, as an example, are presented as follows: (P10B3), where P10 corresponds to teacher number 10 who teaches physics (Table 1); while "B3" corresponds to: a) the category: teachers' conceptions about what to teach and how to teach to promote water sustainability; and, b) the subcategory: didactic strategies in teaching water sustainability (Table 3).

Results

A1. Water problems of the Colombian Amazon

The analysis reveals that the environmental problems related to water in the Colombian Amazon are caused by various causes (see figure 2).

Figure 2. Causes of water problems in the Colombian Amazon



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According to the teachers, the following are the causes of water problems in the Amazon: "disposal of solid waste and wastewater in rivers, logging near water sources, soil erosion due to deforestation" (P10A1). Water resource contamination due to economic activities associated with agroindustry and waste disposal in water sources" (P6A1) is on the rise. In addition, "deforestation is a cause of the decrease and lack of water in certain areas" (P2A1); and, as if that were not enough, "the increase in water consumption generated by various human activities exacerbates the problem of contamination and the decrease in water resources" (P1A1).

In the Colombian Amazon, "it is known that there are people who pollute water sources every time they throw dead animals and water from their garages into the streams. It should be noted that "the water problem increases due to the lack of policies that regulate the disposal of liquid and solid waste in water sources" (P6A1). In line with the above, "in the Amazon region we observe: a) the lack of policies focused on the protection of water sources and; b) the contamination of rivers and streams, as a result of the disposal of sewage without proper treatment" (P7A1).

In the department of Caquetá and, in particular, in the territory of the municipality of El Paujil, they are causes of contamination:

> The expansion of the urban frontier and, in particular, the appearance of human settlements located in areas adjacent to water sources. In addition, the streams are often polluted with waste left over from food processing by families who take walks in these water sources (P5A1).

As a consequence of the water problems described above, in the Colombian Amazon region, there is an "evident decrease of the vital resource, caused by waste, the lack of protection of water sources and the lack of respect for water by current cultures" (P4A1). Indeed, there is an "alteration of the water cycle and rainfall" (P3A1).

A2. The lesson plan for teaching water sustainability.

According to the teachers' conception, the lesson plan to promote water sustainability "is a descriptive document that indicates all the planning tools for activities, contents and evaluative processes that should be used during classes to make sustainable use of the ecosystems present in the territories" (P2A2, P8A2). Likewise, "this plan represents the opportunity to work in the classroom on problems close to the socio-cultural context of the student and offers the possibility of analyzing situations of interest that allow enriching the relationships of the teacher-student-knowledge triad" (P1A2).

Similarly, the lesson plan is "a pedagogical and didactic strategy to promote actions and raise awareness among students about water sustainability" (P12A2); because, from the school context "we work with the bases of society and establish the tasks to be undertaken in the care, preservation and proper use of this precious water resource" (P9A2). This plan also "offers the possibility of diagnosing the situation in different contexts, understanding the reality of water problems at the global, regional and local levels and, of course, visualizing alternative solutions for the protection of this precious liquid" (P7A2).
In accordance with the above:

> a lesson plan comprises the sequence of tasks that promote the development of activities with the objective of contextualizing, structuring, applying and evaluating the knowledge that students have and the knowledge that is to be imparted on the sustainable use of this essential resource for life (P5A2).

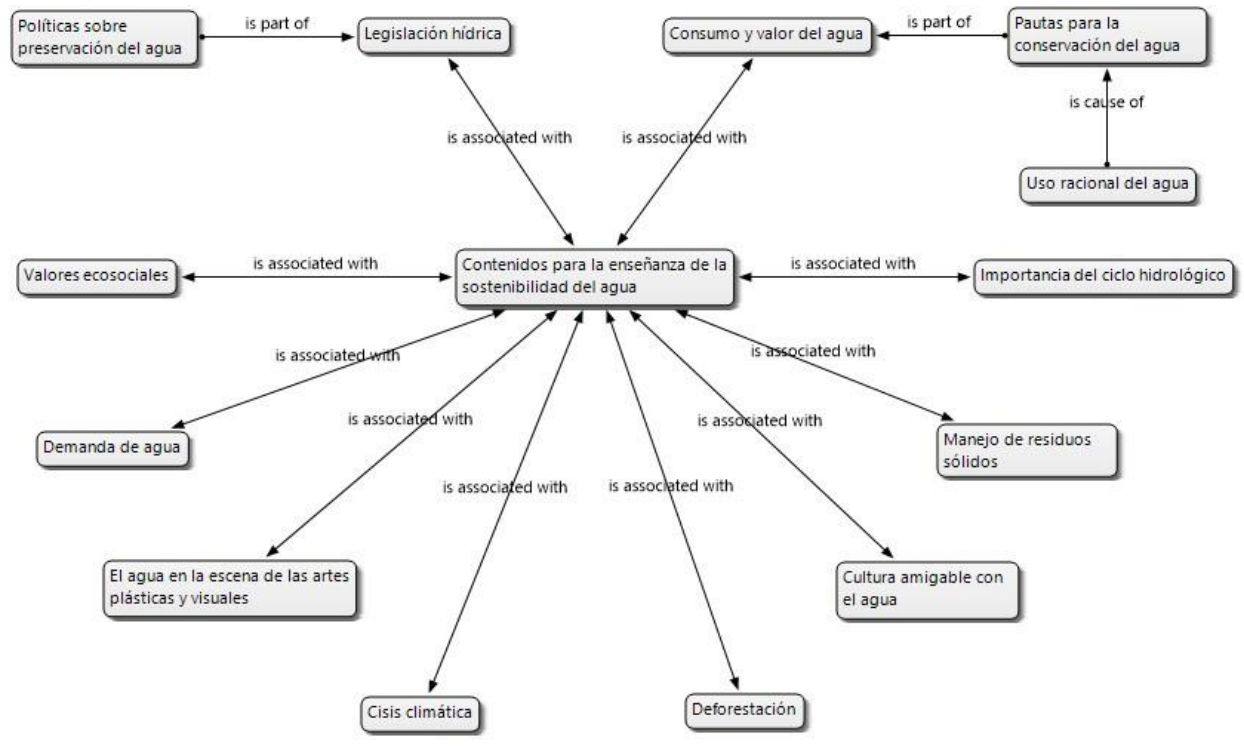
Therefore, teachers consider the "need to design lesson plans from educational institutions in order to promote actions to benefit water and mitigate the impact of water pollution and the environmental problems it generates" (P6A2).

Given the importance of the lesson plan, it can become a means for environmental conservation. In addition, "it is a good way to guide and educate the population regarding water sustainability, and to relate several areas in terms of preserving water sources" (P9A2).

B1. Content for teaching water sustainability.

Regarding the contents of the lesson plan (see Figure 3), the English teacher maintains that it should broaden the students' conceptions about the páramo, runoff, among other knowledge related to the sustainable use of water. Likewise, he indicates the relevance of carrying out projects to build training routes and, above all, also include a lecture that provides guidance on the legislation related to the protection of moorlands and water sources (P7B1).

Figure 3. Suggested contents for teaching water sustainability.



Source. Own elaboration based on Atlas.Ti

The teachers, from the field of mathematics, state that it is essential to deepen knowledge about "the concept of water, uses and necessity of this resource to sustain life, problems of water misuse, guidelines for water conservation, water composition, pH or acidity level, solid, liquid and gaseous states" (P5B1); also, in statistics it is possible to "find out how much the students' families consume and how much they pay for the water service from the interpretation of the bills" (P1B1).

To continue, in social work we can "work on the indiscriminate deforestation of forests, solid waste management, global warming and the rational use of water" (P1B1); in the same area, moreover,

> "The *program* can incorporate topics related to legislation on water management at the national and international levels, study government policies on water conservation, and learn about and participate in the projects that the municipal government is developing for the conservation of this valuable element" (P3B1).

In line with the above, contextualized contents contribute to improve the water situation of the region (Pineda and Pinto, 2018), otherwise, they move away from the reality of the learners (Villalobos, 2009).

Likewise, the English teacher interviewed considers that:

> "the responsible use of water represents a significant situation through which different issues can be addressed such as the importance of maintaining the hydrological cycle, present and future water demand, the friendly relationship with water, and actions to improve water resource management" (P4B1).

In this context, the art teacher considers that "it is possible to incorporate specific content into the lesson plan, such as: water as a vital liquid, water in the visual and plastic arts scene, and recycling as an action to contribute to the care of water and the environment" (P11B1). In this dynamic, the conceptions of the teacher in this area show "the relevance of water in living beings".

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In the same vein, the physical education teacher proposes working on "conservation, protection and use of water" (P9B1). Now, turning to the contents to be incorporated into the ethics classroom plan, the following topics are proposed: "responsibility, solidarity, love for others and other eco-social aspects" (P8B1).

With a general vision, the physics teacher considers that "in any subject, students can be taught the proper use of water, because more importance should be given to strategies, readings and activities related to the sustainability of water resources, rather than to specific content" (P10B1).
What was expressed by the physics teacher is also shared by the language teacher, when she affirms that, "the topic of water is quite broad, so it can be related to any activity that is performed" (P6B1). Based on the contributions of the language teacher, it is inferred that the sustainable use of water can be incorporated in all the contents that are normally addressed because it is a topic that facilitates the execution of any projected activity; this shows that from this area it is possible to read, analyze and produce narrative texts (stories, fables, myths and legends), informative, expository and argumentative texts.

B2. Student input in teaching water sustainability.
When contrasting the teachers' answers, it is inferred that "in the educational context it is important to count on the students' contributions to define relevant activities and strategies towards the transformation of people's actions regarding water issues" (P3B2). In this order of ideas, "it is convenient to consider the students' point of view to guarantee the participation of the actors involved and thus promote communication, generate questions and confront arguments that allow addressing water sustainability" (P1B2). In line with the above, the natural sciences teacher considers "it is essential to take into account the interests of students in the design, implementation and evaluation of any training process related to water care" (P2B2).

In general, teachers value the students' contributions to the solution of water systems problems. This is a sensible conception of the teachers, since teaching that ignores the interests of the students limits their propositionality and autonomy (Not, 1994). In this context, the philosophy teacher affirms that "the students' contributions are necessary within a project" (P3B2); because "the students can make significant contributions to improve the ways of using water in their homes and, with this, contribute to the change of culture in the municipality" (P10B2). Thus, "it is convenient to know the students' contributions and propositions in the planning of the area, in such a way that a guide is built to direct the formative process associated to water care" (P8B2, P7B2).

With the same logic, the social studies teacher expresses that "students' contributions are important in a pedagogical and didactic strategy that seeks to promote knowledge and actions to improve water sustainability" (P12B2). Indeed, "it is convenient to incorporate students' contributions to the curriculum, since it is known that students have valuable knowledge about water use" (P9B2, P13B2).

With reference to the topic in question, "a valuable strategy is to consider the students' knowledge and skills so that they can express their ideas both in and out of the academic environment" (P5B2). Similarly, the art teacher "considers it important to know the students' appreciations, proposals and initiatives to carry out a work on water as a vital element of every living being" (P11B2).

B3. Didactic strategies for teaching water sustainability.
In the area of social sciences, "a project that addresses an environmental issue related to the wetland surrounding the school can be implemented as a relevant pedagogical strategy to promote learning about the sustainable use of water" (P3B3).

In the area of English, "this universal language is strategic to make the water problem visible through a website and activate a voice of change, both in the Institution and in the world, to optimize water consumption" (P4B3). In addition, a didactic strategy in the area of English

> "It may contain the following phases: a) contextualization, which consists of explaining the activity; b) application, in which students develop the activity; c) exposition, a space is created for students to present the results of the activity to the group; and d) feedback, which should be led by the teacher, but with the participation of the entire class" (P7B3).

According to what has been stated, the contributions of mathematics teachers reveal that it is necessary to:

> "(a) to carry out projects that involve different educational actors beyond the teacher-student-knowledge triad; b) work under the approach of problem situations, with the purpose of building a learning scenario in which students inquire about water issues, ask questions and propose investigations that strengthen critical thinking; c) design didactic material to promote water care among students" (P1B3).

In addition to the above,

> "didactic strategies can be incorporated such as collecting different water samples and then measuring their pH, and comparing it with the level of drinking water, which is 7; then, students can generate a series of statistical tables to analyze the degree of contamination of the resource they consume" (P5B3).

In the area of art, it is pertinent to implement strategies such as the "creation of artistic exhibitions whose costumes are made with recycled elements to prevent them from being disposed of in the region's water sources" (P11B3); with the same vision, the ethics teacher proposes to carry out "activities such as plays, songs and stories" (P8B3).

Moving forward, in the area of language, it is proposed to carry out activities mediated by*:* "readings and analysis of texts related to water, presentation of videos and field trips to promote research and arouse curiosity in students about the sustainability of water resources" (P6B3).

In a complementary way, the teacher in the area of physics proposes:

> Conduct field practices for students to connect with the natural environment, enjoy its wonders and protect the environment; as well as analyze topics on water use, for example, how many liters per hour reach the homes of each student (P10B3).

In the same direction, in the area of social studies, it is proposed to: *a)* implement field work so that students learn about the state of water sources and become the protagonist of their learning; b) carry out activities aimed at mitigating the current situation of inadequate water use (P12B3).

It is convenient, as expressed by the physical education and agroecology teachers, "to dedicate some time in class to promote the importance of the adequate use of water" (P9B3); and, in this way:
a) "to carry out a diagnosis of the social representations of the student body on the sustainable use of water resources; b) to intervene to contribute to the sustainable use of water, and c) to evaluate the impact of the proposal presented" (P13B3).

B4. Research in teaching water sustainability.
In mathematics, "research can be encouraged as long as the student is motivated to participate in the solution of the different problems inherent to water. In this way, students strengthen competencies such as communication, ask questions and develop their critical thinking skills". When students assume "the role of researchers, they know what information to look for, how they are going to do it, and how they will present their results" (P1B4).

In other words, research is a necessary strategy to promote awareness and relevant actions for water sustainability in students (P5B4). According to Amahmid *et al.* (2018), research operates as a pedagogical strategy to analyze and contribute to the solution of water issues. Indeed, the social studies teacher considers that "through research, it is possible to better understand the water situation of the region". Accordingly, "research projects turn students into managers of their own learning"*;* thus, research involves students in the improvement of water systems (Jiménez-Oyola *et al.*, 2021).

From this logic, in the natural sciences it is convenient to "incorporate research in teaching as a starting point, since students can be involved in the execution of an environmental project" (P2B4). Indeed, research encourages students to think for themselves (Kemmis, 1993).

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Something similar occurs with English teachers, who consider that "research motivates students to get involved in activities associated with water protection" (P7B4); thus, "research is the path to development and will always allow progress, for that reason it is essential that the institution implements research projects because it will have a greater impact on the promotion of the adequate use of water" (P4B4). In the case of language,

> "Research is a teaching strategy that motivates to explore, observe, analyze, discover, process data, communicate and support opinions. In addition, the study forges in the students skills such as curiosity and creativity, which are necessary to contribute to the solution of water resource problems" (P6B4).

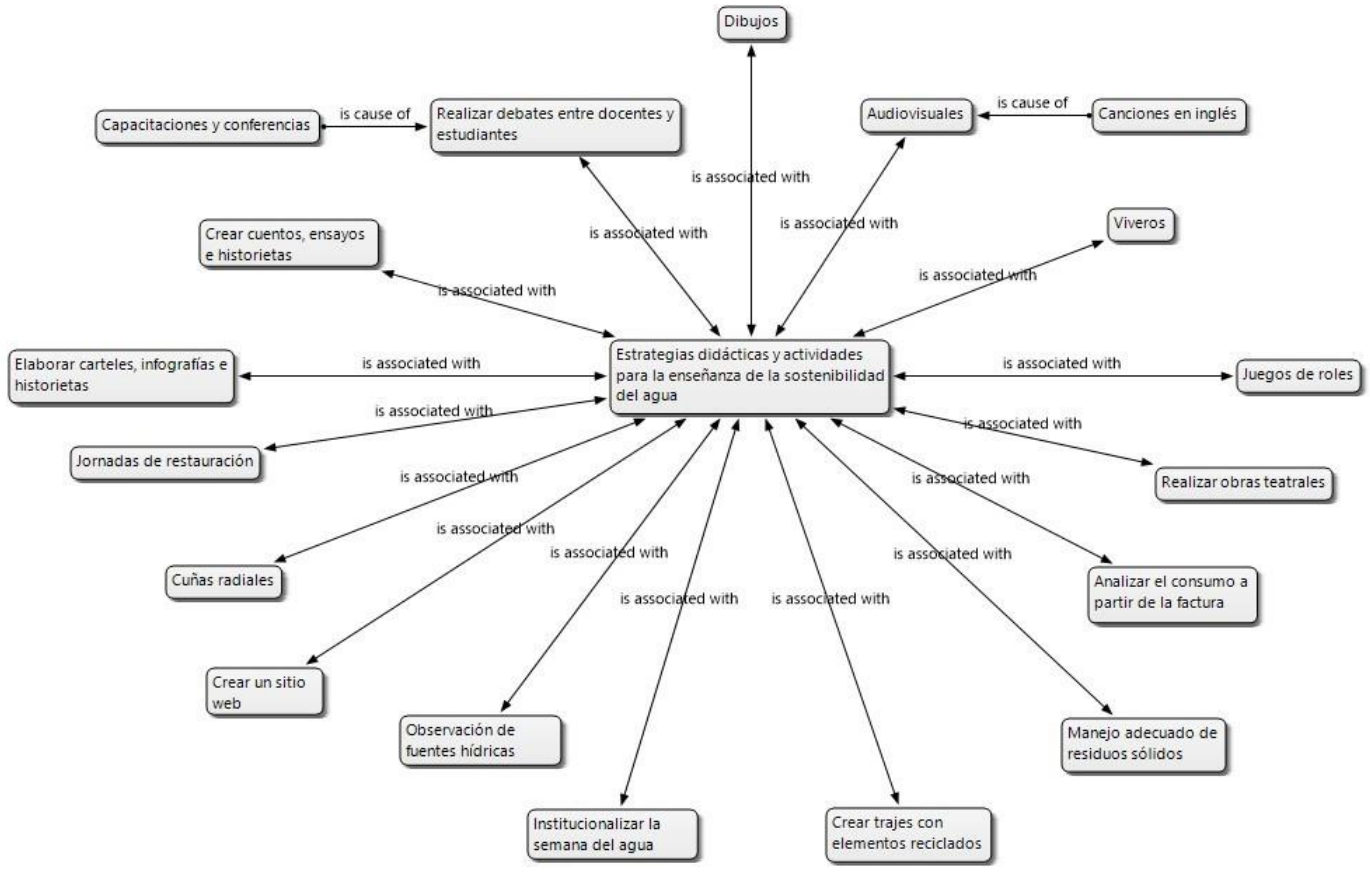
Similarly, in ethics, "research is assumed in teaching as a necessary strategy to gain in-depth knowledge of water issues" (P8B4) through the collection and analysis of information, the organization of materials and the development of reports (Robottom, 2010).

Something similar is expressed by teachers of physical education, art education, agroecology and physics, who agree in saying that "the development of research projects allows involving several areas; thus, the whole institution can "talk about water sustainability" (P10B4); so that, "through the studies, the causes of the water problem are identified" (P13B4), and knowledge is generated based on criteria of rigor and usefulness (Sauvé, 2010), which can be incorporated into the lesson plans. Thus, "a research project can be carried out that involves students in water issues, for example, how to conserve, protect and make good use of water" (P9B4), "how to use this natural element in the creation of artistic elements" (P11B4).

B5. Activities for teaching water sustainability

The teachers consider that "various activities can be carried out to generate a culture of water conservation" (see Figure 4), "through training, conferences, workshops and courses that emphasize the causes of the problem of water resource pollution and scarcity" (P5B5). As a complement to the above, "students can carry out related activities such as observing, analyzing and reflecting on the importance of water" (P10B5).

Figure 4. Recommended activities in teaching water sustainability.



Source. Own elaboration based on Atlas.Ti

For their part, teachers state that it is feasible to carry out activities related to: "a) identification of water problems; b) observation of water sources; c) asking people what they think about the water situation in the region" (P3B5); "d) field trips to learn about the current situation of water sources; e) good solid waste management in the context where they interact, and, f) carrying out reforestation activities" (P12B5).

It should be noted that,

> "The area of language allows encouraging students to learn about the adequate use of water through the development of activities such as: reading, analyzing and producing narrative texts (stories, fables, myths and legends), informative, expository and argumentative texts; promoting debates, interviews, conferences and speeches on water conservation; design and elaboration of posters, infographics and cartoons; workshops, games and videos" (P6B5).

In the same sense, in physical education "activities such as readings, posters and contests on the reasonable use of water can be carried out" (P9B5). In addition, "they can create comics, role-play, and write songs in English" (P7B5).

Continuing with the theme, the ethics area can "program visits to water sources" (P8B5). In the same direction and in the interest of better illustrating, the art education teacher presents the following list of activities*:*

> "a) create an audiovisual exhibition to set the mood for water week; b) create visual pieces with short messages on the use and care of water; c) plant trees at the La Turbia water source, which crosses the IEAA; d) create drawings in which water sustainability is the central theme; e) broadcast radio spots that will be transmitted by the school radio station" (P11B5).

In the same sense, the activities that could be developed from the areas of English and art, would be, for example: "a) analyze the problems generated by the misuse of water in the institution, in order to provide solutions" (P4B5), and b) "institutionalize the water week, in which the different areas will carry out their work related to the sustainability of the vital liquid" *(*P11B5).

B6. Interdisciplinarity in teaching water sustainability.

According to the opinion of the natural sciences teacher, "interdisciplinarity is an essential input in the design and execution processes of a project related to the sustainable use of water" (P1B6). Additionally, the statistics teacher states that an interdisciplinary pedagogical proposal should consider the "following aspects: a) the areas of knowledge to be worked on; b) the roles and responsibilities of the participants; c) the spaces to disseminate the findings; and d) the levels of training involved in the development of the work" (P1B6).

In line with the above, the English teacher considers "the implementation of an interdisciplinary didactic strategy that impacts students in the knowledge of water issues, so important nowadays, but which is only superficially addressed in schools and from some specific areas" (P4B6).

To better illustrate, the math teacher argues that the different areas can be united to teach students to conserve water and, as an example, she mentions that*:*

> "a) in mathematics we can work with data and measurements of water volume*; b)* in language we can present reports; c) in biology it is possible to address issues related to ecosystems and life; *d)* in social studies it is convenient to study the history of the population; e) in geography it is relevant to know the water sources that are close to the school, and f) in physics and chemistry we can take measurements of water pH" (P5B6).

In contrast to the above, according to Casagrande *et al.* (2021), the absence of interdisciplinary dialogue leads to the isolation of the areas of study and, consequently, generates the fragmentation of knowledge (Magendzo, 2003). Whereas, the collegial work of the areas around the water situation motivates students to develop attitudes towards the measured use of water (Meireles *et al.*, 2018). In this perspective, philosophy and social studies teachers state that, "it is convenient to design and implement an interdisciplinary didactic strategy

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to link the different areas of knowledge around the development of activities to mitigate the problems related to the use of water as an important element for life" (P12B6); in this way it is possible to "stimulate knowledge and actions for the conservation of this vital liquid" (P3B6).

In summary, interdisciplinarity demands an institutional culture of collegial and supportive work of the areas (Sauvé, 2013), in which each discipline of knowledge contributes its initiatives to address situations such as water waste and pollution (Ortega *et al.*, 2016). From this logic, teachers interpret interdisciplinarity as an integrating strategy of the areas around the problem of water systems in the Amazon region. In the words of Martínez (2006), it is necessary that all areas train students in respect for nature.

B7. Assessment in teaching water sustainability.

"Evaluation, being a dynamic process, must consider cognitive and non-cognitive aspects (emotions, attitudes)" (P10B7). Likewise, "it is the opportunity to assess the work done by the student in the educational process" (P5B7); within this framework, "evaluation should determine the evidence and criteria for student learning when working individually or with others" (P1B7).

In order to better illustrate, as an example, in the evaluation process we can "carry out activities such as recording videos that show the collection of water samples; then, use reagents to measure the pH of these samples and, subsequently, elaborate data tables that favor the analysis of the information" (P5B7); in addition to the above, some evaluation strategies that can be implemented to encourage the motivation of students towards the proper use of water are: "evidence portfolios, project development, videos on the tasks *developed*" (P12B7), as well as "rubrics and poster contest whose theme is the reasonable use of this water resource" (P9B7).

In this regard, it is appropriate to say: "evaluation from the very beginning and throughout the process is a very effective strategy, because through it, students present and expose their products as they progress" (P6B7). Thus, evaluation strategies can be directly related to students' daily actions, for example, "when a student stops throwing garbage on the floor or picks up a piece of paper from the floor, it is evident that he/she understood and reflected on his/her actions and their consequences" (P10B7). In this way, "the level of understanding and responsibility for the management of sustainable water use can be verified" (P13B7).

According to the art teacher, an evaluation strategy to implement consists of "encouraging students to participate in the planned tasks to make adequate use of water" (P11B7). For its part, in the area of English "we can value what students do at home, at school and in the environment with respect to water care" (P4B7). In the area of ethics, "questions can be asked to measure knowledge, identify and reinforce weaknesses inherent to water sustainability" (P8B7).

Discussion

According to Flórez-Sterling *et al.* (2021), the following principles underlie the systemic curriculum for water sustainability: a) curricular transversality of water issues (Magendzo, 2003; Yildirim and Semiz, 2019); b) interdisciplinarity that favors the collegial work of the areas around the proper use of water resources (Amahmid *et al...,* 2018); c) research on water issues (Uehara and Ynacay-Nye, 2018); d) school autonomy that encourages the definition of water resource conservation strategies (Wei and Luo, 2020); e) community propositionality in the transformation of the environment (Luhmann, 2007); f) lesson plans, activities and methodologies defined in Law 115 of 1994 (Congress of the Republic of Colombia, 1994); g) favorable attitudes of teachers and students towards water sustainability (Meireles *et al.*, 2018).

Consistent with the teachers' conceptions, the factors that aggravate the water problem in the Colombian Amazon are: a) deforestation of forests; b) indiscriminate exploitation of natural resources through mining and oil extraction; c) inadequate use of water; d) lack of treatment of solid and liquid waste; e) lack of political will to promote water protection programs; f) the lack of water conservation programs; g) the lack of water treatment; and h) the lack of water conservation programs in the Colombian Amazon.
f) the disposal of chemicals, garbage and wastewater in water sources. According to the professors, the Amazon rainforest is replaced by grasslands for cattle grazing (Spera *et al.*, 2016), which accelerates water pollution (Ortega *et al.*, 2016).

Regarding the lesson plan inherent to the systemic curriculum, teachers make the following descriptions: a) document that integrates the various activities and contents planned to promote water sustainability in a given area; b) program to guide students in raising awareness; c) alternative methodology adhered to the curriculum; d) strategy to start with awareness and generation of awareness in the proper use of the vital liquid; e) document to promote activities in favor of water conservation and care. Similarly, Figueroa *et al.* (2016) describes the lesson plan as the route established by the teacher to work in the classroom.

According to Pineda and Pinto (2018), it is convenient to implement didactic strategies that contribute to the promotion of water culture in the educational community. In this way, a resource that the community has, but that gradually increases the levels of contamination and decrease in the flow of water sources, can be protected through digital platforms (social networks) and the planning of outings, with the objective of recognizing the current state of water sources and motivating the execution of actions favorable to water sustainability.

On the other hand, research as a teaching and learning strategy makes it possible to identify the causes of the problems affecting water sources and to propose efficient solutions for their conservation. In this school context, teachers and students use research as a pedagogical strategy to solve local and regional water problems. Thus, students can collect and analyze data to build valid and relevant knowledge (Robottom, 2010; Sauvé, 2010).

It is also important to highlight that teachers propose various activities that can be implemented in each area of knowledge, among these we can highlight: a) development of environmental and water conservation talks; b) scheduling of *on-site* practices; c) planting trees in the watersheds of streams; d) activation of nurseries; e) recycling programs; f) solid waste collection days. In addition to this, activities such as writing essays on the surrounding water (Havu-Nuutinen *et al.*, 2017), visiting water sources (Coban *et al.*, 2011), debates, workshops and trainings (Prasad *et al.*, 2020), rainwater harvesting and utilization (Silva *et al.*, 2019; Campos-Cardoso *et al.*, 2020) can be promoted. According to Suárez-Arias (2012), the environmental dimension should be specified in the curriculum and in the contents of all disciplines.

In this way, interdisciplinarity allows interconnecting the areas of the curriculum through thematic axes such as pollution, abatement and water waste (Mora, 2012; Yıldırım *et al.*, 2019). From this logic, the school forges in students attitudes favorable to water sustainability (Marinho *et al.*, 2014; Coban *et al.*, 2011; Xiong *et al.*, 2016; Benninghaus *et al.*, 2018; Meireles *et al.*, 2018; Bagoly-Simó *et al.*, 2018).

On the other hand, the evaluative strategies make it possible to assess the students' attitudes towards mitigating the current problem of inadequate water use. From this point of view, the formative strategies consider the students' actions at home, at school and in the general environment.

Conclusions

The systemic curriculum for the sustainability of water is an autonomous and interstructuring proposal based on the proposition of IEAA's secondary school teachers with the purpose of contributing, from the school, to the solution of the water problem in the Amazon, whose causes, according to the teachers' conceptions, are: The causes, according to the teachers, are: disproportionate use of water, construction of houses on land adjacent to rivers and streams, deforestation affecting the water cycle, inoperability of environmental authorities to implement water protection policies, pollution generated by the disposal in water sources of: a) decomposing animals, b) waste from chicken and pig farms, c) leftover food waste from outings. The structure of the systemic curriculum is supported by the lesson plan, which is described by the teachers as a pedagogical guide in which the contents, didactic strategies, actions, task sequence and evaluation processes to be implemented in all the compulsory and fundamental areas of secondary education (Article 23 of Law 115 of 1994) are made explicit, in order to promote water sustainability.

The teaching of water sustainability is evidenced in contents and concrete actions such as guidelines for water conservation; determination of household water consumption based on the interpretation of bills with the purpose of proposing reduction strategies; proper disposal of solid waste in the household; and the use of water at home.

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containers; provision of drinking fountains in the school to reduce the consumption of bottled water; study of water legislation and regional water conservation policies; creation of a water club in the school; writing stories, plays and essays on water care; educational outings to learn about water ecosystems; germination of seedlings in the school nursery to later plant them in the creek basins; create posters, drawings and infographics related to water care; broadcast radio programs on the school and municipal radio station; reuse of washing machine water to clean sidewalks and toilets.

Interdisciplinarity, inherent to the systemic curriculum, is an opportunity for collegial work among teachers, with the purpose of reaching consensus on pedagogical and research projects, didactic strategies and concrete actions to be implemented for the benefit of water preservation. In this purpose, research operates as a pertinent didactic strategy to determine the causes, consequences and alternative solutions to the water problem in the Amazon region, in the search for promoting concrete attitudes of students such as: taking advantage of rainwater to reduce consumption, avoiding cutting down trees near water sources, using water sparingly, repairing leaks, and not pouring polluting liquids into pipes.

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