

Contributing water pollution control through the use of selected instructional strategies amongst secondary school students

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ABSTRACT

The problems that exist within society are not only economic or political but also environmental. The increase in flooding, climate change, and desertification requires urgent attention, hence the need for coordinated efforts to help solve environmental problems. This study is targeted at students at the secondary school level based on the principle of “catching them young”. The paper highlights some of the effects of water pollution, including the direct or indirect effect on humans as a result of the consumption of contaminated plants or animals. As a method of controlling environmental pollution, schools, communities, nongovernmental organizations, and the public should collaborate and emphasis should be placed on the need to conserve our natural resources and the synergy that exists between the environment and water. The study is qualitative in nature and strategies for effective teaching of water pollution in a classroom setting are discussed, which include analogies, pictorial and photo analysis and the use of value clarification. The results of the study are presented under the following headings: (i) students’ experience, (ii) reactions and responses, and (iii) intention towards future implementation. The results indicate that students were excited about the developed instructional strategy. Water and environmental education are briefly discussed and its broad aim highlighted, which is to help people comprehend their ecological environment. The paper concludes by recommending that there should be proper monitoring, regulation, and control of the environment to combat water pollution and the media and non-governmental organizations should intensify efforts to create awareness on the dangers of environmental problems.

Keywords: Water pollution; Environmental education; Water protection; Water pollution control; Instructional strategies

1. Introduction

The task of every society is to create a cleaner environment for present and future generations. However, existing human activities on the environment indicates that people are not aware of the need to make conscious efforts to fulfill this challenging task. This article was created based on the concern that “a livable environment cannot be left to future

generations”. In this paper, effective classroom management and effective teaching strategies for sustainability are discussed. In this way, it is thought that a new environmental behavior model will be created for students.

Water pollution can be defined in many ways. According to Woodford [1], water pollution is usually a situation where one or more substances have been built up in water to such

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an extent that they cause problems for living creatures. According to a general definition, water pollution is the addition of a substance to the water by humans that alters its chemical composition, temperature, or microbial composition to such an extent that harm occurs to resident organisms or humans [2]. Water pollution can also be regarded as one of the most significant adverse effects on water bodies such as lakes, rivers, oceans, and groundwater caused by an individual's routine activities [3]. Water is considered to be polluted when changes are made to its quality or composition either naturally or as a result of human activities so as to become less suitable for drinking, domestic, agricultural, industrial, recreational, wildlife and other uses for which it would have been otherwise suitable in its natural or unmodified state [4]. When people think of water quality, they consider the kinds and amounts of substances that are dissolved or suspended in it. It is the concentration of these substances that determines the water quality and its suitability for particular purposes [5,6].

Water pollution is related to both the pollutant and the solvent property of the water. The solubility of water depends on the nature of the substance. Organic substances such as sugar, urea, alcohol, and most ionic substances can dissolve in water. However, it does not dissolve oils, hydrocarbons and some salts. Waste materials mixed with water are bio-oxidated with the help of some bacteria and converted into a harmless state. For harmless conversion, certain groups of bacteria and excess dissolved oxygen must be present in the water. In cases where inorganic, organic and toxic substances are discharged into rivers, lakes, and seas, the oxygen in the water decreases. With oxygen depletion, bacteria die and water sources become contaminated [7–9]. The Tbilisi Declaration of 1978 presented a challenge to environmental educationists to increase awareness and raise values amongst humankind to improve the quality of life and the environment at large.

For the protection of nature, protection of water and the spread of the concept of a sustainable environment, an environmental education with the appropriate curriculum adopting the right teaching techniques can be beneficial. In light of this information, this study aims to advance the understanding of teachers regarding various teaching strategies about environmental education that will help students' understanding of knowledge related to certain environmental concepts.

2. Literature review

2.1. Water pollutants

Water pollution comes from different sources and can affect the lives of many different living creatures. The contents of water pollutants and their sources are given in Table 1 [5].

2.2. Effects of water pollution

In the 21st century, when famine and hunger threaten the world, the most important strategic resources are soil and water resources. Unfortunately, agricultural pollutants, industrial wastes, and domestic wastes, as well as unplanned and excess water use, make it difficult to preserve and sustain

the existing ecosystem [10]. Several chemicals that mix and are found in water can have toxic effects. Diseases such as cholera and typhoid are transmitted from person to person in this way. When these microorganisms mix with human feces, they can cause other people who drink water to become ill. Health institutions regularly check samples taken from water sources [11].

Many people discard garbage from homes and offices into streams, lakes, rivers, and oceans, thereby endangering the lives of water animals. These items include cans, paper, plastic, furniture, and other household materials. When plastics are dumped into lakes and rivers, this can present serious risks to ducks, as they might be strangled and when dumped in the oceans, dolphins could be killed. Aluminum cans can cut animals living in water bodies.

Water pollution affects human health directly by drinking or indirectly by consuming contaminated plants or animals. Disease-causing (pathogens) microorganisms, such as bacteria, viruses, and protozoa can cause diseases such as diarrhea, cholera, polio, typhoid fever, guinea worm, dysentery, gastroenteritis, roundworms and others in either human or other animal hosts. According to Krantz and Kifferstein [12], it is estimated that nearly 1.5 billion people lack safe drinking water and that at least 5 million deaths per year can be attributed to waterborne diseases.

Pollution is harmful to aquatic life and reduces its activities and reproductive abilities. Chemicals from industries such as metals and solvents are poisonous to fish and other aquatic organisms. Insecticides and herbicides used for agricultural purposes and in homes contain toxic chemicals. During rainfall, these chemicals are carried into water bodies by rainwater runoff and they can accumulate in fish and shellfish, subsequently poisoning people and other animals that eat them. Materials such as detergents and oils float on water and not only spoil the appearance of the water body, but can also become toxic. Many chemical pollutants also have unpleasant odors [13,14].

Phosphorous, nitrogen, and potassium, which are necessary for plant growth, can be found in higher concentrations in untreated wastewater. When added to lakes and streams, they promote the growth of aquatic weeds as well as "blooms" of algae, which are microscopic plants. Weeds can make a lake unsuitable for swimming and boating. Moreover, these weeds and algae can also decay and become biodegradable materials and "food" for anaerobic bacteria leading to oxygen depletion [15,16].

Silt-bearing runoff from many activities including construction sites, deforestation and agriculture can prevent the penetration of sunlight through the water body, restricting photosynthesis and causing blanketing of the lake or river bed and in turn damaging the ecosystem. Some particles suspended in water (particulate matter) eventually settle and form silt or mud at the bottom. This sediment can decrease the depth of the body of water. If there significant amounts of biodegradable materials in the sediment, it will contribute to the problem of eutrophication. Toxic materials can also accumulate in the sediment and affect the organisms living there as well as the fish that feed on them and other animals that consume the fish [17,18].

An increase in water temperature (thermal pollution), which can result from warm water from factories and power

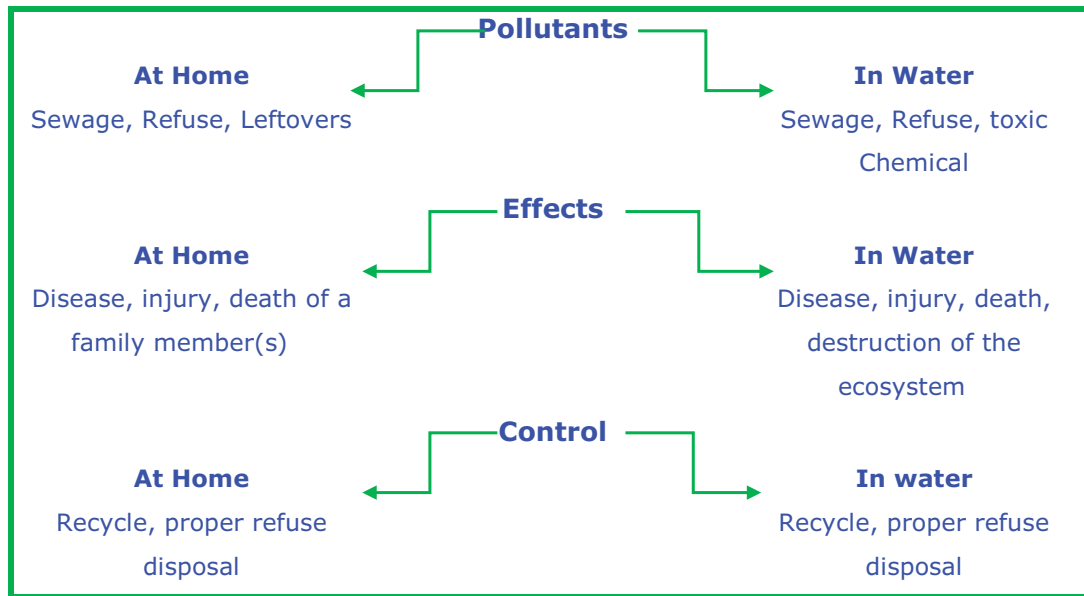


Fig. 1. Schematic configuration of water pollution.

plants, can result in the deaths of many aquatic organisms including fish. By raising the temperature of the water, thermal pollution reduces the amount of oxygen dissolved in the water, thus also reducing the level of aquatic life that the water body can support [19].

The effects of water pollution are not only devastating to people but also kill animals. Consequently, it can also be said that the effects of water pollution pose a serious threat to society both today and in the future. Perhaps the most important reason for developing worldwide efforts to monitor and restrict global pollution is the fact that most forms of pollution do not respect national boundaries. Woodford [1] stated: "one of the biggest problems with water pollution is its trans-boundary nature. Many rivers cross countries, while seas span whole continents. Pollution discharged by factories in one country with poor environmental standards can cause problems in neighboring nations". Holistic steps must be taken to address the water pollution challenge, and this must start from the classroom through a proper instructional strategy, as outlined in this paper.

2.3. Prevention and control of water pollution

Pollution control approaches will depend on the type of pollutants, the source of pollution and the effects of pollution [5,6]. The type of pollutants can be degradable or non-degradable materials. Degradable matters include domestic sewage, fertilizer, and some industrial wastes, while non-degradable materials include pesticides, petroleum products, sulfur dioxide, hydrocarbons, and radioactive materials, metals such as lead, mercury, and fluorine. The source of pollution comes from industries, farmlands, etc.

Degradable waste materials can be easily broken down through biochemical reactions into simple, non-polluting substances such as carbon dioxide and nitrogen. However, this natural control process is only possible provided the rate at which pollutant materials enter the water bodies or

groundwater does not exceed their natural capacity to assimilate them (eutrophication can occur if the pollution load becomes high) [20].

To safeguard used water from damaging water resources, individuals have to devise methods through which these pollutants are removed before they enter the environment. In urban areas in most developed countries, the wastewater from homes, businesses, and factories are collected by a system of underground pipes (sewers) which carry it to one or more central treatment facilities. Most of these systems are placed near bodies of water into which the treated wastewater is to be discharged. Pollution from factories or wastewater treatment plants is controlled through regulations that require the treatment of a facility's wastewater before it is discharged into a nearby lake or stream [21,22].

With the awareness of how important water is for the continuation of life, individuals have great responsibilities in providing healthy drinking water and a livable environment for future generations. The first step in government interventions to prevent water pollution is to establish pollution standards. In addition, solid wastes that may cause contamination in surface and groundwater should be disposed of by various methods [23]. The wastewater in the settlements should be disposed of after passing through the treatment stations. Filter and treatment plants should be installed in the factories. In production, materials that will not harm the nature should be used. The condition of the environment should be improved. For example, some measures that can be taken in gulfs with low water exchange potential may make it possible to dilute the pollutants less by increasing water circulation.

2.4. Water education and environmental education

Water resources have faced major problems in the last century. The fact that water quality is rapidly deteriorating in addition to water scarcity is an alarming issue worldwide [24].

Table 1
Types of pollutants and their sources

	Water pollutants	Sources
Organic water pollutants	Sewage and livestock droppings	City sewage system/livestock operations
	Petroleum oil spillage, fuel, oil, etc.	Oil drilling sites
	Tree and bush debris	Logging operation
	Microplastics (pellets, fragments, fibers and composed of diverse polymers)	Marine environment
	Nanoparticles	Industrial discharge
	Persistent organic pollutants (pesticides, solvents, pharmaceuticals, and industrial chemicals)	Industrial activities
Inorganic water pollutants	Acidity	Industrial discharge
	Fertilizer	Farmland
	Heavy metal	Mine sites
	Insecticides and herbicides	Farmland
	Hot water	Industrial discharge
Large-scale pollutants	Garbage such as paper, plastic or food waste	Industrial discharge
	Various plastics carried by ships	Marine environment
	Shipwrecks	Marine environment

These problems are very important because they lead to further problems making a domino effect in terms of social and economic as well as ecological aspects [25]. In particular, water sources obtained from drinking and potable water, domestic and industrial wastes, over-fertilization, unconscious pesticides are under the influence of excessive population growth and urbanization [24,26,27].

Environmental education aims to help people to comprehend their ecological environment, to develop an understanding of societies living in harmony with the world and to help them acquire the necessary skills for effective and responsible participation [28]. Water education aims to provide people with water awareness and the habit of using water carefully. "Education" plays an important role in efforts to solve environmental and water problems. To solve water and environmental problems, some behavioral changes should be made and awareness should be raised. The target audience in environmental and water education is not only students but all people. In achieving the aim of education, schools have an important role in the structure of the formal education system, which gives individuals the desired behavior from an early age [29].

Individuals can develop their attitudes towards water consumption and water use in a positive way via increased awareness and training on issues such as the importance of water, water as a source of life, metabolism, and water, global warming, ground and surface water, pollution and decrease in water. Auriault [30] stated that the objectives of water education are as follows:

- To provide information on water resources, usage, pollution, protection, and management.
- To gain attitudes and behaviors on the conservation of water resources and the efficient use of water.
- To assume personal and social responsibility for the protection of water resources and pollution reduction and to ensure the participation of individuals.

In case of deterioration in the physical and human environment, communities should be given environmental awareness by using all kinds of educational opportunities to understand the significant problems they could face. The most important condition for accessing environmental awareness is the fundamental change in one's social behavior. This is only possible with an effective and comprehensive environmental education [31].

3. Methodology

This study was completed with qualitative research methods used in social sciences. In the prevention of water pollution, the quality of environmental education and instructional strategies has been descriptively identified. The execution of this method was formed with the case study design. The phenomenology pattern focuses on cases that are aware of but do not have an in-depth and detailed understanding. The phenomena can be seen in various forms such as events, experiences, perceptions, orientations, concepts, and situations in the living world. These cases can be encountered in various ways in daily life. Phenomenology is the conscious experience of people's worlds; in other words, everyday life and social action and how people make sense of their experience [32]. The data related to water pollution control chosen as the phenomenon of this study was obtained by document analysis and evaluated with descriptive analysis.

4. Results

4.1. Instructional strategy

To effectively teach water pollution to young learners, it is necessary to consider learning theories related to this level of education. Jean Piaget's concrete and formal operational stages are most applicable to this set of learners since they

range from 9 to 14 years of age. The age-range limit of 12–14 years retains most of the formal operational stage characteristics. Thus, learners are expected to learn by description, explanation, classification, assumption realities, correlation, hypothesis formulation, prediction through assertions and influences [33,34]. Teachers need not be rigid in the formal operational stage but must be pragmatic in using relevant instructional materials where necessary. Verbalization is the form of explanation is necessary. This aids internalization and makes experiences (seeing, touching, feeling) much more meaningful for the learners [35].

4.1.1. Analogy

Doit [36] asserts that “Analogies are best used when the target domain is most difficult to understand”. Analogy, therefore, will be appropriate for teaching pollution in general and water pollution in particular. An analogy is a mapping between similar features of concepts, principles, and formulae. The analogy is aimed at teaching an unknown concept from the vintage view of known and familiar concepts to complex [37]. Three steps are required for the effective use of analogies:

- Analyze the reading task facing the children and the concept required;
- Construct appropriate analogies;
- Review the guide with the students so that they can form a retrieval clue for the target concept.

These three steps involve the identification of the concept (water pollution) and the construction of analogies that they can visualize at home (human habitat and aquatic habitat). The identification of water pollutants is given in Figure 1 [38–40]:

4.1.2. Teaching water pollution using pictorial and photo-analysis

The teacher must be ready to collect useful pictures from magazines, newspapers, and photographs that are related to the concept stated for discussion [41]. The steps involved are as follows:

- The teacher should introduce water pollution to the students.
- Students should be guided to interact with the pictures by explaining what they see or understand from the pictures one by one and illustrating the concept.
- The teacher picks the picture one by one and illustrates the concept.

4.1.3. Teaching water pollution using values clarification

The values clarification method uses the personal values of students on a given concept to teach the concept in detail. It also helps in resolving students’ value conflicts. Value clarification helps students to engage in the active formulation and examination of values of a concept or issue through the rational thinking and emotional awareness process [42]. A visit to an actual site nearby may be of added benefit as

learners can see and obtain first-hand information on the effects of their unconscious actions on their environment. The steps involved in values clarification are written below:

- The teacher assists students in listing some of their actions that can lead to the present situation, especially water pollution.
- A teacher helps students to collect and organize facts.
- The truth of the facts is accessed.
- Learners take tentative value decisions.

4.2. Inference of instructional strategy

4.2.1. Students experience

Students perceived the environment as integral to their existence. Materials used in teaching the concept (water pollution) were readily available in the environment. The personalized support students received from their teachers served to address variations in terms of how they (students) perceived the environment and particularly water pollution [43]. Students described their time during the lesson as brainstorming, working out how to help conserve the natural resources in the environment. Student’s experiences in nature study were brought to the fore and the experience was perceived to be worthwhile.

4.2.2. Reactions and responses

During the teaching in the class, the conversation naturally moved to reactions (the reflective level) with students appearing eager to move from perceived to active listeners, describing their experience toward reflecting on their experiences and trying to make amends in the future. Students used words such as “wonderful”, “crucial”, “amazing” to express their mood at the cause of teaching water pollution using the selected instructional strategies as already mentioned in the methodology.

4.2.3. Intention towards future implementation

The focus of teaching particularly in relation to value clarification is the future. Thus, decisional level questions were used to achieve an understanding of how students planned to apply what they had learned in the future and their intentions regarding how to control water pollution. Students generally indicated a readiness to implement what they had learned in the classroom. Many students expressed willingness towards proper disposal and recycling of household waste in order not to affect aquatic lives.

5. Discussion and implications

One of the dangers inherent to environmental problems is the decrease in surface and ground waters. In recent years, a shortage of water has appeared because the population has increased rapidly and climate conditions and rising industrialization have impacted limited water sources. The most important and lasting potential solution for the water and environmental problems that have appeared in the hemisphere is undoubtedly educating people [44].

Students perceived the environment as an integral part of their existence on earth. The instructional strategies mentioned not only increased teachers' pedagogical content knowledge of the environment for sustainable development but also promoted teachers' interaction and contributed to the development of professional learning communities within schools [45]. According to Kadji-Beltran et al. [46], the personalized support students received from teachers at the cause of teaching served to address the variation in students' individual initial needs and how they perceived the environment throughout their lives; therefore, a good foundation at the junior school level is necessary to change the students' world view.

One area of importance noted by the authors in this study was the feeling of self-confidence and competence, a finding similar to a research conducted by Loucks-Horsely [47] on teacher mentoring. Thus, selecting an instructional strategy to teach water pollution and the accompanying affective impacts described by the authors in this study seems to have the potential to help students feel excited about their studies thereby energizing and fueling them to bring their skill and talent fully to life [48].

6. Conclusion

The environment is constantly changing. However, as the environment changes so does the need to become aware of the problems that surround it. In this paper, the strategies for teaching water pollution are discussed. The water problems and how to control or prevent them are identified. Besides these, this paper discussed water pollution and identified its consequences. Various teaching strategies were also presented for teaching the concept, including analogies, concept mapping, pictorial and photo-analysis and values clarification. Through these, learners are not only made aware of the effects of water pollution, but practicable actions to be taken to avoid were listed, while other actions are expected to arise in the application of these strategies in the classroom. This is aimed at changing the attitude of learners positively towards pollution control.

The paper concludes by calling on schools, communities, and non-governmental organizations to embark on a vigorous campaign to enlighten the public on the importance of the natural resources in our environment and the need to conserve them. It is recommended that environmental education as a course should be an integral part of the curriculum at all levels of education, and trained personnel should be provided by the government. Human beings should be part of the water pollution clean-up efforts. Education, whether formal or informal has an important role in this regard. Increasing awareness or highlighting the problem represents the important first steps in solving it. Greater public awareness can make a positive difference. In line with this information, the municipalities and the district governors in charge of the local government in the region should complete the necessary planning studies and the educators in the schools in the region should provide environmental and water awareness-raising, awareness and informative training to the students. Furthermore, families should be educated about environmental awareness and water consumption. It is recommended that both non-governmental organizations and

the media in the region should continue their activities by increasing their sensitivity level to raise the level of awareness on the subject and to raise public awareness about the environment and water.

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