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The Awareness Degree of the Principles and Applications of Green Chemistry among Students of Scientific Colleges at University of Bisha

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Abstract

The study aimed to reveal the awareness degree of the principles and applications of green chemistry among the students of scientific colleges at Bisha University. The descriptive (survey) approach was adopted to achieve the study's objectives. The sample consisted of (168) male and female students from the scientific sections in the Colleges of (Medicine, Engineering, Applied Medical Sciences, Computers and Information Technology, and Science) at the University of Bisha. A scale of green chemistry awareness principles and applications was built considering the literature on green chemistry. It consisted of (12) principles and (95) applications related to them. The study reached many results; the level of awareness of the principles and applications of green chemistry among science students at the University of Bisha is weak. The students obtained an average of (4.036) of the total score on the scale, which amounted to (12) points, with a percentage of (33.63%). There are no differences between the students' average scores and the other colleges. There are statistically significant differences at the level of significance (0.01) between the students' average scores on the scale for only four principles. The study presented many recommendations and suggestions.

Keywords: *Awareness degree, principles and applications of green chemistry, scientific colleges, university of bisha.*

Introduction and Sense of the Problem

The environment and its problems and issues impose themselves urgently everywhere, locally and globally. The need has emerged to establish, many laws and legislation that regulate man's relationship with the environment. It also has developed and introduced new trends in chemistry that are less dangerous to human health and have less impact on the environment and its resources. The environment is suffering greatly from harmful human activities. The environmental problems that the world is currently suffering from are global warming, hazardous waste, the expansion of the ozone hole, radioactivity, loss of biodiversity, pollution, and the continued exposure of humans to chemicals that are of their own making, and other environmental problems. These problems have led to emergence of a contemporary trend, including green technology at all educational levels. This is why green chemistry sought to make the science of chemistry an integrated science, by reducing what is caused by chemical manufacturing, which is important for the pharmaceutical industries. The pharmaceutical, petroleum, and plastic industries are less polluting, and less expensive, by applying some of its principles such as: reducing waste, using catalysts instead of using excess reagents, using safe solvents, and chemicals that decompose after use instead of accumulating in the environment (Ablan, 2006, Nawar, 2015, and Al-Ayasra, 2017). Effective safety measures that prevent pollution should be used. Green chemistry solutions should be used wherever possible to prevent water pollution. One effective way to deal with the problem of water pollution is to use less harmful methods of eliminating contaminants. Interesting examples of remediation have been provided to help correct groundwater contamination by arsenic, which affects approximately 200 million people worldwide. New approaches to water pollution prevention and treatment involving radical reaction and the use of nanoparticles have been included (Ahuja, 2013).

Many names have been given to this new science of chemistry: green chemistry, Sustainable Chemistry, Clean chemistry, and Benign design chemistry. The term green chemistry is the most widely used, and clear. The literature has included many definitions of green chemistry. The first one believes that green chemistry is a science and a strategy. Among the definitions that represent this trend are stated by: (Manahan, 2006; Ameta & Dandia, 2014 & Anastas, Cullipher, 2015 and Ramachandran et al., 2007; Ul-Haq et al., 2023). It is concerned with the optimal utilization of chemical products in the industry and ways to reduce or

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minimize the use or production of substances harmful to health. It is also the science of practicing chemical sciences and manufacturing processes in a sustainable, safe, and non-polluting manner while consuming small amounts of materials and energy and producing little or no waste materials. It is a new branch of chemistry that works to develop environmentally friendly processes such as the use of safe solvents, the use of supercritical fluids, and the use of safe catalysts that assist in cleanup processes in chemical reactions. The second believes that green chemistry represents methods for manufacturing chemical products. The use of chemistry to prevent pollution through the design of environmentally benign chemical products and processes. Chemical reactions are environmentally benign and do not produce byproducts that pollute the atmosphere. Chemical technologies and methods that reduce or prevent the use of raw materials or by-products resulting from a chemical reaction, solvents, or catalysts in manufacturing. It would be dangerous to humans or harmful to the environment. The first trend focused on clarifying the nature of green chemistry. The aim it seeks to achieve is preventing pollution and preserving the environment. The definitions of the second trend focus on how to conduct chemical reactions using safe raw materials, solvents, and catalysts in chemical manufacturing processes.

Experiments of using green chemistry to address environmental problems were developed by scientists such as Paul Anastas and John Warner at the University of Oxford who developed 12 principles for green chemistry (Anastas & Warner, 1998). These principles are Pollution Prevention. It is preferable to prevent the formation of residues and waste at the source rather than treating or disposing of them after their formation. The atom economy is the designing of preparation methods so that most reactants combine to form the final product. The less dangerous chemical reaction designing is the manufacturing designing methods that the initiating and resulting reaction materials have the least toxicity or are not dangerous to the environment or human health. Designing safer chemicals: The chemical product should be characterized by the highest degree of functional efficiency and safe solvents and treatments. The design for energy efficiency should be considered due to its cost and environmental impact. It is preferable to design reactions that take place at normal temperatures. Raw materials containing the starting materials should be renewable rather than depleting non-renewable materials; and reducing chemical derivatives. Unnecessary physical and chemical operations such as derivatization of particular groups or temporary modifications in molecules should be avoided, as well as stimulating factors (Catalysis). It is preferable to use specialized catalysts rather than simply stoichiometric reaction ratios; and to produce degradable and decomposable materials. Products are designed so that they do not settle in the environment after performing their function, but rather must be able to decompose in the environment into simple, harmless substances; and real-time analysis to prevent pollution. Chemical analysis methods are developed to keep up with the real-time reaction to control the chemical reaction before any hazardous materials are formed.

In pollution prevention chemistry, Chemicals that are safe in type and composition are selected to reduce the possibility of chemical accidents such as gas releases, explosions, or fires. (Culipher, 2015) (Roberts, 2005). Therefore, Miller (2012) stresses the necessity of integrating green chemistry and its applications into curricula to enhance and build a generation of scientifically educated youth, capable of effectively participating in society and solving its problems. Braun et al. (2006) and Karbudewan, Roth & Ismail (2015) point to the significance of using green chemistry to link chemistry concepts to the environment, in which the student lives. It works to develop his higher cognitive skills such as communication skills, problem-solving skills, and decision-making ability. It helps build awareness and a sense of environmental and social responsibility, in addition to achieving the ultimate goal of sustainable development. This was confirmed by Al-Omari's (2008) study, which aimed to identify the level of awareness of science teachers in the city of Tabuk regarding the global environmental situation, especially what is related to pollution and environmental safety. The results showed that the levels of global environmental awareness, awareness of the problem of environmental pollution, and awareness of the importance of environmental health and safety are average. The study of Al-Shaili and Al-Ruba'ani (2010) showed that the level of awareness of climate variables among student teachers was high. Mohammed's study (2020) aimed to prepare a proposed curriculum in science based on the principles of green chemistry and its applications to develop awareness of environmental sustainability and positive thinking among middle school students. Hajjaj's study (2020) aimed to develop chemistry curricula in the chemistry teacher preparation program in colleges of education in light of the principles of green chemistry and its applications. Al-Azab's study (2020) aimed to measure

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the effectiveness of a proposed unit in green technology to acquire concepts and develop an awareness of it.

The fields of green chemistry application include the manufacture of paper, plastics, and detergents. There are many applications of green chemistry in this field, including paper manufacturing, plastics manufacturing, polymer manufacturing, detergent manufacturing, and green plastics manufacturing. The field of cleaning clothes and purifying water. There are many applications of green chemistry in this field. These applications include (cleaning clothes, purifying water, removing pollutants from water, using ultrasonic technology, and solving the problem of groundwater pollution). There is also the field of energy and chemical industry. This field includes biomass; microwave energy; solar energy systems; and the alternative fuel industry (Abdul Moez, 2007; Nawar, 2015, and Shaker, 2009). Green chemistry applications appear in all fields and contribute to solving many environmental problems, especially water, air, and soil pollution problems. They also work to achieve sustainable development, progress, and community development. All this is done through the good reuse of the environment's resources or the use of alternative environmentally friendly resources. This necessitates attention to include these principles and applications at the university level, in scientific curricula in general and the chemistry curriculum in particular.

There are many manifestations of interest in the principles and applications of green chemistry, as listed in the following:

First: Holding many international and Arab conferences and seminars on green chemistry, its principles, and applications. Including the Green Chemistry and Sustainability Conference in Berlin (Germany) from April 4-6, 2016. The 6th International Chemistry Conference entitled "New Trends in Chemistry" was held in Riyadh, Saudi Arabia, from 8-10 November 2016. The 3rd International Conference on Sustainable Green Chemistry, held in Berlin, Germany, from 14-17 May 2017. The 8th International Conference on Sustainable Green Chemistry will be held from 23-26 July 2017, which was held in Victoria, Australia. The 9th Green Chemistry Conference was held in New Zealand from 8-9 December 2017. The fifth conference entitled "Chemistry for a Better Future" in the State of Kuwait on March 12, 2018. The second international conference entitled "Green Chemistry and Engineering" was held in Barcelona, Spain, from 23-24 July 2018. The Third International Scientific Conference entitled "Science for Life" was held in Al-Ghardaga, Egypt, from 12-15 November 2019. It recommended paying attention to the global trend towards green chemistry and its applications to achieve sustainable development and a safe future. It also recommended the trend towards green economies and harmful waste management methods. It stressed the role of green chemistry, in addressing different environmental issues and problems.

Second: The interest of some previous studies and researches that emphasized the necessity of integrating green chemistry and its applications into curricula at all educational levels. Including the study of Abdel Wahab (2011). A proposed program for electronic waste using interactive hypermedia to develop knowledge about it, decision-making about it, and self-motivation for learning among first-year secondary school students. In addition to Gross's study, (2013), the study Cullipher's study, (2015), the study of Karpudewan et al (2015), and Hajjaj's study (2020). Some studies have emphasized the construction of a proposed unit or a proposed program in light of green chemistry, such as Ghanem's study (2015), Nawar's study (2015), Saleh's study (2016), and Al-Shami's study (2018). Many studies and researches have also shown interest in studying and employing the principles of green chemistry and its applications in curricula and educational programs. These studies include Abdul Rahman's study (2005), Loger's study (2011), Salem's study (2013), Gross's study (2013). Cullipher's study (2015) and Jad Al-Haq's study (2018) aimed to design a program in chemical innovations to develop chemical awareness among student teachers at the College of Education for preparing green chemistry curricula that institutions can adopt to include green chemistry in curricula. Fawzi's study (2012) aimed to clarify the importance of the principles and applications of green chemistry in organic chemistry to reduce the effects of chemical materials and processes on environmental balance and human health. Abu Al-Wafa's study (2018) aimed to identify the effectiveness of a green chemistry course based on the principles of sustainable development (ESD) in developing chemical culture among a sample of students from the College of Education. The program topics included some applications of green technology (Green Chemistry - Nanotechnology).

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There is a lack of studies and research, that focus on the university stage. Most studies focused on the secondary stage, such as the study of Abdul Rahman (2005), the study of Ghanem (2015), the study of Nawar (2015), and the study of Saleh (2016). Many studies and researches have focused on using green chemistry and its applications in various scientific fields. The rapid developments in discoveries require a review of university student preparation programs, especially in scientific colleges, and working to develop them in light of green chemistry. Therefore, curriculum development should stem from the learners' lives, their environment, and the experiences they have therein. Students then participate in developing these experiences and gaining more knowledge and skills while learning about the environment in which they live. So that they can interact with it in a fruitful way that leads them to acquire educational experiences that help them in their continuous work to serve the environment and work to develop and preserve it (Abdul Fattah, 2003). Student preparation programs based on green chemistry are programs related to the learner's reality. Students study the issues and problems present in the environment surrounding them. These programs seek to prepare the contemporary person with an integrated personality, to interact with the requirements of the future. The programs help people develop their lives, deal with the different aspects of problems, study the multiple solutions, and choose the most appropriate solution to make sound decisions regarding these problems (Hajjaj, 2020).

Green chemistry plays an important role in the lives of societies and in protecting the environment in the long term for future generations, its inclusion in science curricula in general, and chemistry curricula in particular, has become an urgent necessity in the educational process. It can contribute to preparing individuals capable of dealing with the data of this society and solving its environmental problems. This requires the creation and development of new study plans and programs at the university and pre-university levels, in a way that supports educational outcomes, encourages scientific research, and keeps up with everything new in the field of specialization.

Many countries have sought to include the concept, principles, and applications of green chemistry in many chemistry curricula and programs at all educational levels, especially the university level. In the United States of America: Green chemistry awareness is being raised through, the inclusion of a set of activities in the twelfth-grade curriculum. Green Chemistry includes three topics (Introduction to Green Chemistry - Green Chemistry in Industry - Safe Experiments. In China: Green Chemistry is a mandatory course in grades 10, 11, and 12. The curriculum content includes the following topics: green chemistry, biodegradable plastics, industrial processes, and atomic economy. The curriculum seeks to increase safety in schools, understand the effects of chemicals on society and the environment, reduce waste and lower costs in laboratories, develop scientific research and scientific knowledge, and encourage lifelong learning and student participation in community development through the development of the chemical industry and improvement of the education system (Habibi, Sabbaghanb & Mohammed, 2013). In the UK: The Department of Chemistry at the University of York offers various green chemistry techniques, energy and environmental topics, greener chemical processes, and clean chemistry technology. Many green chemistry principles are also included in undergraduate laboratory education. They are included to achieve the aims of the sustainable laboratory program, by replacing hazardous, unsustainable chemicals with sustainable and safe materials (Dodson, Summerton, Hunt & Clark, 2014). At the University of Nottingham, a course on green chemistry and its processes is taught in the first year of the Chemistry Department, covering the principles of green chemistry and chemical industries. In Indonesia: Green chemistry principles were integrated into the teaching of general chemistry in the first year of the Islamic State University of Indonesia, (Hamidah, Zamhari & Eilks, 2018). In Spain: The University of Scranton has integrated green chemistry topics into its curriculum, especially the Environmental Chemistry course taught in the third year at the university. In the Kingdom of Saudi Arabia: Umm Al-Qura University has included the green chemistry course in the undergraduate curriculum. This course is taught in the first semester of the fourth year, along with some elective courses, including advanced polymers, catalyst applications, and detergent chemistry. The curriculum and syllabus meet the minimum requirements for industrial chemical professionals, preparing graduates to be specialized chemical practitioners, working efficiently in factories, and qualifying them for success in the work environment.

Many studies have been conducted in the field of awareness, including the study of Al-Omari (2008). It aimed to identify the awareness level of science teachers in Tabuk regarding the global environmental situation, especially pollution and environmental safety. The results showed that the levels of global

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environmental awareness, awareness of the problem of environmental pollution, and awareness of the importance of environmental health and safety were average, in a sample of (94) teachers. The study of Al-Shaili and Al-Ruba'ani (2010) aimed to investigate the level of awareness of climate change among student teachers. They were (127) students in the field of science and social studies at Sultan Qaboos University. The results showed that the level of awareness of climate change among student teachers was high. Saleh's study (2016) aimed to reveal the effect of a proposed curriculum in light of green chemistry concepts on developing both environmental awareness and environmental decision-making among first-year secondary school students. Al-Ayasrah's study (2017) aimed to investigate the level of environmental awareness, of the phenomenon of global warming among science teachers in the primary stage in government schools in Amman. The results showed that the level of environmental awareness, of the phenomenon of global warming among science teachers in the primary stage is medium. Abul-Wafa's study (2018) aimed to reveal the effectiveness of a proposed green chemistry course based on the principles of education for sustainable development (ESD) in developing chemical culture among student teachers in the chemistry department. Al-Shami's study (2018) aimed to reveal the effect of a professional development program for green chemistry teachers on developing their problem-solving skills and understanding of environmental concepts. Cullipher's study, 2015, aims to design green chemistry courses and include them in some curricula to develop decision-making skills and awareness of environmental issues among students. Mohammed's study (2020) aimed to prepare a proposed curriculum in science based on the principles of green chemistry and its applications to develop awareness of environmental sustainability and positive thinking among intermediate school students in Egypt. Al-Azab's study (2020) aimed to measure the effectiveness of a proposed unit in green technology to acquire concepts and develop its awareness. The study of Suleiman Al-Aziz (2020) focused on building a proposed unit in light of sustainable development and the green economy to provide students of the scientific sections at the College of Education with some concepts related to the green economy and sustainable trends.

The above results show that there is a strong relationship between chemistry and environmental problems. The environmental use of chemistry and the conduct of dangerous chemical reactions cause environmental problems. Then these problems should be solved. Therefore, many efforts and reforms have emerged to achieve this. The most important is the emergence of a new branch of chemistry; Green Chemistry. Many countries globally and locally, are interested in including green chemistry and its applications in curricula and study programs. Green chemistry also achieves the connection and integration, between the different branches of chemistry; such as analytical chemistry, inorganic chemistry, organic chemistry, biochemistry, and physical chemistry. Most international and Arab conferences confirm the necessity of keeping pace with scientific and technical progress in the field of chemistry. They also confirm striving to provide scientific means capable of achieving development, and discussing ways to advance the educational and research process by focusing on chemical innovations to meet modern industries and develop the skills of graduates in chemistry. Among the most important of these innovations is the interest in the principles of green chemistry.

It was necessary to reveal the level of awareness of the principles and applications of green chemistry among a sample of scientific colleges at Bisha University, who are aware of the environmental issues and problems they face. This research sought to achieve, and focus on developing some courses in the student preparation program at university colleges in light of the principles of green chemistry and its applications, as it is one of the modern chemical innovations in the twenty-first century. The researchers also conducted an exploratory study that aimed to initially examine some specialized courses and chemistry, especially in the program for preparing students of some scientific colleges (medicine, engineering, applied medical sciences, computers, and information technology and sciences) at Bisha University according to the principles of green chemistry and its applications. It was found that there is a deficiency in including many principles and applications of green chemistry in the student preparation program courses, especially the chemistry course. Here, the importance of including the principles and applications of green chemistry in the chemistry courses of the science colleges' preparation program appears, which provides treatment for environmental problems and issues and how to avoid them. Despite this interest in the principles and applications of green chemistry, there is no study - to the extent that researchers have seen - that aims to measure the degree of awareness of the principles and applications of green chemistry among science college students.

The Research Problem:

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The problem was represented in university students' weak familiarity, especially in the scientific colleges in Bisha, with the principles and applications of green chemistry and its role in sustainable development. Upon initial examination of some of the courses that contain topics in chemistry, it was noted that they did not include the principles and applications of green chemistry related to them.

The Research Questions:

The study answers the following questions:

1-What are the principles and applications of green chemistry that students of scientific colleges at the University of Bisha should be familiar with?

2. What is the awareness degree of the principles and applications of green chemistry among the students of scientific colleges at the University of Bisha?

3. Are there differences in awareness of the principles and applications of green chemistry among students of scientific colleges at the University of Bisha attributed to the college variable?

The Research Objectives:

The study endeavors to achieve the following objectives:

1. Determine the principles and applications of green chemistry that should be available to students of scientific colleges at the University of Bisha.

2. Reveal the awareness degree of the principles and applications of green chemistry that should be provided to students of scientific colleges at the University of Bisha.

3. To check whether there are differences in awareness of the principles and applications of green chemistry among students of scientific colleges at the University of Bisha attributed to the college variable.

Significance of the Study:

The study may benefit:

1- Those responsible for preparing educational programs, designing curricula, and developing them in scientific colleges to deepen this trend toward increasing awareness of the principles and applications of green chemistry in a way that reflects the dimensions of sustainable development and the Kingdom's Vision 2030.

2- University students have an interest and orientation towards a new concept, green chemistry, which leads to green education through the developments of the modern era and the development of countries and its development among all students, especially at the university level.

The Study Limits:

The study is limited to the following:

- Objective limit: The degree of awareness of the principles and applications of green chemistry among students of scientific colleges at the University of Bisha.

- Place limits: Scientific colleges (Medicine, Engineering, Applied Medical Science, Computers and Information Technology, and Science) at the University of Bisha.

- Time limits: The second semester in the academic year 1445/2024 AD.

- Human limits: Students at scientific colleges at the University of Bisha.

The Study Terms: The terms associated with the study were defined as follows:

- Green Chemistry: It is concerned with the optimal use of chemical products in industry. It is also a way to reduce the use or production of substances harmful to health. It should be through designing production processes to obtain the final product using safe environmental alternatives that work to prevent pollution.

- The degree of awareness of the principles and applications of green chemistry: The level of students in the colleges of medicine, engineering, applied medical sciences, computers and information technology,

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and sciences at the University of Bisha. They possess knowledge and experience with the principles of green chemistry and the uses of applications associated with it. It is measured by the degree to which it is obtained according to the scale prepared for this purpose.

The procedures of the study: To answer the research questions, the following procedures are followed:

First: Preparing a list of green chemistry applications in light of its principles: To answer the first question of the current study: What are the principles and applications of green chemistry that students of scientific colleges at the University of Bisha should be familiar with? A list of principles and applications of green chemistry has been prepared according to the following steps:

1-Determine the objective of preparing the list: The objective of the list is to identify the applications of green chemistry in each of the principles of green chemistry and to benefit from them in preparing a measure of the awareness degree of the principles and applications of green chemistry that should be available to students of the scientific colleges at the University of Bisha.

2- Identify the sources for derivation of the list: The items for the list of the principles of green chemistry and its applications were derived from the theoretical framework of green chemistry, its concept, origins, principles, and applications. It is also derived from the previous studies that dealt with the principles of green chemistry and its applications.

3- Scientific control of the list: The list was presented to a group of arbitrators in the field of curricula and methods of teaching science in colleges of education, and the teaching staff of chemistry in colleges of science, judge the extent of its validity in terms of the suitability of each of these principles for university students in scientific colleges. The extent of their correlation to each of these principles and the applications to which they belong.

4- Prepare the final form of the list: After making the necessary amendments in light of previous opinions, the list reached its final form. It includes (12) principles of green chemistry and (95) related applications. The following table explains the answer to the first question.

Table 1. List of green chemistry principles and applications in its final form.

S	Principle	Number of Applications
1	Prevention	5
2	Atom economy	2
3	synthesis of less hazardous chemical	12
4	Designing safer chemicals	11
5	Safer solvents using	12
6	Design for energy efficiency	9
7	Use of renewable feedstocks	17
8	Reduce derivatives	3
9	use of catalysis	9
11	Design for degradation	5
12	Real-time analysis for pollution prevention	4
12	Accident prevention chemistry	6
-	The total	95

Second: Study methodology: The descriptive survey approach was used.

Third: The study community: The community includes all students of scientific colleges (medicine, engineering, applied medical sciences, computers and information technology, and sciences) at the University of Bisha. It reached 6369 students who were enrolled in the academic year 1445/2024.

Fourth: Study sample: The random sample was (168) students from scientific colleges (medicine, engineering, applied medical sciences, computers and information technology, and sciences at the University of Bisha

Table 2. Distribution of the study sample after the application according to the college for each of them.

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College	Medicine	Engineering	Applied Medical Sciences	Computers and Information	Sciences	Total
Frequencies	26	53	25	37	27	168
%	15.48%	31.55%	14.88%	22.02%	16.07%	100%

Fifth, the study tool: The tool is defined as: "How the researcher collects information that enables him to answer the study questions and test its hypotheses" (Al-Assaf, 1427). It is also defined as: "A set of questions that may be open or closed, or both (closed and open at the same time), directed to members of the study community; to collect information related to the objectives, questions, and hypotheses of the study." (Al-Sarihi et al, 2008). The researchers used a scale for this study entitled "A scale of awareness of the principles and applications of green chemistry among science students at the University of Bisha." It was prepared according to the following procedures: study the theoretical framework and review the educational literature related to green chemistry. Review previous studies related to green chemistry and some of the tools included in the previous studies, in addition to the researchers' experience. The scale was prepared in its initial form and consists of the first part which included the initial data of the respondents. It included the name, specialization, and college for each of them. The second part of the scale included (12) multiple-choice questions to measure the awareness of the principles and applications of green chemistry among students of the scientific groups at the University of Bisha. One question was presented for each of the twelve identified principles in the study. Therefore, the maximum value of the scale was (12) degrees.

Validity and reliability of the study tool:

-The apparent validity of the study tool: The researchers presented the tool to a group of academic reviewers in many Saudi universities with experience and specialization in the field. The tool was reviewed to ensure the linguistic suitability and correctness of the vocabulary, and the extent of its relationship to the scale as a whole. Also to check the principles that were developed to measure to be measured. The amendments were made, and some of them were agreed upon by more than 80% of the arbitrators.

-Internal consistency validity: Pearson correlation coefficients were extracted between the scores of each item. The scale total score in the exploratory sample reached (30) students of the science sections at the University of Bisha. The results are shown in the following table.

Table 3. The correlation coefficient between the score of each statement and the total scores of the scale.

Statement	Correlation coefficient	phrase	Correlation coefficient	phrase	Correlation coefficient
1	0.863**	5	0.639**	9	0.832**
2	0.725**	6	0.638**	10	0.569**
3	0.624**	7	0.745**	11	0.627**
4	0.711**	8	0.805**	12	0.608**

Note: (** Correlation coefficient is significant at 0.01.

Table (3) shows the correlation coefficients between the scores of each statement and the total scale scores. They are significant at the level of significance (0.01), which confirms the connection of the statements to the scale as a whole. This indicates the presence of internal consistency in the scale's statements.

The stability of the scale: To ensure the stability of the study tool, the researchers calculated the reliability coefficient using the Alpha-Cronbach coefficient method. It reached (0.816), which is a high-reliability coefficient. Therefore, the scale can be trusted when it was used as a tool in the current study.

The Results of the Study:

To answer the second question: "What is the awareness degree of the principles and applications of green chemistry among the students of scientific colleges at the University of Bisha? The researchers calculated the number of students who answered correctly each principle of the twelve principles, the percentages, the mean, and the standard deviation of the student's grades. Table (4) shows the results each principle and the scale as a whole.

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Table 4. The degree of awareness of the principles and applications of green chemistry among science students at the University of Bisha (n = 168).

Rank	No	Principle	Correct answer		Wrong answer		SMA	SD
			Q	%	Q	%		
8	1	Prevention	53	31.5	115	68.5	0.315	0.47
2	2	Atom economy	77	45.8	91	54.2	0.458	0.50
11	3	synthesis of less hazardous chemical	39	23.3	129	76.8	0.232	0.42
7	4	Designing safer chemicals	57	33.9	111	66.1	0.339	0.47
4	5	Safer solvents using	63	37.5	105	62.5	0.375	0.49
5	6	Design for energy efficiency	61	36.3	107	63.7	0.363	0.48
9	7	Use of renewable feedstocks	50	29.8	118	70.2	0.298	0.46
10	8	Reduce derivatives	47	28	121	72	0.280	0.45
1	9	use of catalysis	78	46.4	90	53.6	0.264	0.50
6	10	Design for degradation	58	34.5	110	65.5	0.345	0.48
12	11	Real-time analysis for pollution	24	14.3	144	7.85	0.143	0.35
3	12	Accident prevention chemistry	71	42.3	97	57.7	0.423	0.50
the scale as a whole.							4.036	1.74

Table (4) shows that the general arithmetic average for the scale as a whole (awareness of the principles and applications of green chemistry among science students at the University of Bisha) reached (the mean = 4.036, the standard deviation = 1.74, and the percentage 33.63%). This means that the level of awareness among science students at the University of Bisha about the principles and applications of green chemistry is very low. The students obtained an average of (4.036) out of the total score on the scale, which amounted to (12) points, on a percentage of (33.63%). The table also reveals that principle (9), which states: "use of catalysis," achieved the highest average of students' grades and came in first place. It reached (the mean = 0.464, and the standard deviation = 0.50). The number of students who answered correctly to this item was (78) out of the total number of students (168), with a percentage of (46.4%). This is also a very low percentage, which indicates that this principle gains low awareness. The table also reveals that principle (11), which states: "Real-time analysis for pollution," achieved the lowest mean among students and came in last place. It reached (the mean = 0.143, and the standard deviation = 0.35). The number of students who answered correctly this item was (24) out of the total number of students (168), with a percentage of (14.3%). This is a very low percentage which indicates low awareness of this principle.

A one-way analysis of variance (ANOVA-One Way) test was calculated to answer the third question: "Are there differences in awareness of the principles and applications of green chemistry among science students at the University of Bisha due to the college variable?" The analysis is used to indicate the difference between the averages of the responses of the study sample members on the scale as a whole, and each principle separately, and according to the variable (totality), as shown in Table 5.

Table 5. The Results of the ANOVA test for the significance of the differences between the averages of the responses of the study sample members on the scale as a whole and each principle separately according to the variable (college).

S	Principle	Statement	Sum of Squares	D.F	Mean Squares	F	Significance Level

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1	Prevention	Between groups	0.98	4	.025	1.133	0.343 Not statistically significant
		Within group	35.30	163	0.22		
		The total	26.28	167			
2	Atom economy	Between groups	.041	4	0.10	0.404	Not 0.806 statistically significant
		Within group	41.30	163	0.25		
		The total	41.71	167			
3	synthesis of less hazardous chemical	Between groups	1.70	4	0.43	2.158	0.061 Not statistically significant
		Within group	28.24	163	0.17		
		The total	29.95	167			
4	Designing safer chemicals	Between groups	5.46	4	1.37	6.915	0.01
		Within group	32.20	163	0.20		
		The total	37.66	167			
5	Safer solvents using	Between groups	3.35	4	.084	3.786	0.01
		Within group	36.03	163	0.22		
		The total	39.38	167			
6	Design for energy efficiency	Between groups	3.32	4	0.83	3.809	0.01
		Within group	35.53	163	0.22		
		The total	38.85	167			
7	Use of renewable feedstocks	Between groups	2.09	4	0.52	2.281	0.059 Not statistically significant
		Within group	33.03	163	0.22		
		The total	35.12	167			
8	Reduce derivatives	Between groups	2.19	4	0.55	2.822	0.05
		Within group	31.66	163	0.19		
		The total	33.85	167			
9	use of catalysis	Between groups	3.87	4	0.97	4.158	0.01
		Within group	37.92	163	0.23		
		The total	41.79	167			
10	Design for degradation	Between groups	0.15	4	0.04	0.161	0.958 Not statistically significant
		Within group	37.83	163	0.23		
		The total	37.98	167			
11	Real-time analysis for pollution	Between groups	0.53	4	0.13	1.078	0.369

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		Within group	20.04	163	0.12		Not statistically significant
		The total	20.67	167			
12	Accident prevention chemistry	Between groups	2.37	4	0.59	2.273	0.055 Not statistically significant
		Within group	38.63	163	0.24		
		The total	40.99	167			
	The scale as a whole	Between groups	20.35	4	5.09	1.701	0.152 Not statistically significant
		Within group	487.44	163	2.99		
		The total	507.79	167			

Table (5) illustrates the following: There are statistically significant differences at the level of significance (α ≤ 0.01) between the mean scores of students on the fourth and fifth, sixth and ninth scales (designing safe products - designing safer chemicals), (using safe solvents using), (increasing energy efficiency Design for energy efficiency), and (use of catalysis). There are statistically significant differences at the significance level (α ≤ 0.05) between the mean scores of students on the scale in the eighth principle only (Avoid using derivatives - Reduce derivatives). There are no statistically significant differences at the significance (α ≤ 0.05) between the mean scores of students on the scale as a whole. As well as the principles (the first is the prevention policy - the second is the economics of the atom - the third (designing less hazardous chemical reactions) - the seventh is (the use of renewable feedstocks) - the tenth (the production of biodegradable materials Design for degradation) - the eleventh (Real-time analysis for pollution), and the twelfth (Accident prevention chemistry). To verify the trends of differences and conduct multiple post hoc comparisons to determine the differences between the means, the Schaffé test was used, and the results are shown in the following table.

Table 6. Scheffe test results, between the averages of students' responses according to the college variable.

	College	**SMA**	**Engineering**	**Medical Sciences**	**Computers and information**	**sciences**
Fourth	Medicine	0.07	0.232	0.486*	0.190	0.541*
	Engineering	0.30		0.263	o.033	0.318
	Medical Sciences	0.056			0.296	0.055
	Computers and information	0.26				0.351*
	sciences	0.62				
	College	0.07	0.439*	0.286	0.360*	0.311
Fifth	Medicine	0.51		0.154	0.080	0.129
	Engineering	0.36			0.074	0.025
	Medical Sciences	0.43				0.049
	Computers and information	0.38				
	College	0.15	0.233	0.310	0.233	0.476*
Sixth	Medicine	0.30		0.023	0.099	0.143
	Engineering	0.32			0.076	0.166

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	Medical Sciences	0.40				0.242
	Computers and information	0.63				
	College	0.08	0.184	0.201	0.217	0.405*
Eighth	Medicine	0.30		0.017	0.033	0.220
	Engineering	0.28			0.016	0.203
	Medical Sciences	0.26				0.187
	Computers and information	0.48				
Ninth	Sciences	0.70	0.406*	0.304	0.138	0.396
	College	0.30		0.103	0.269	0.010
	Medicine	0.40			0.166	0.092
	Engineering	0.57				0.258
	Medical Sciences	0.31				

Note: *Indicates that there are statistically significant differences at the level of (0.05).

Table (6) indicates that:

- Regarding the fourth principle (Designing safer chemicals): There are differences between students' mean scores in the College of (Medicine - Applied Medical Sciences) in favor of students in the College of Applied Medical Sciences. There are also differences between the grades of students in the College of (Medicine - Sciences) in favor of students in the College of Science, as well as the presence of differences between the grades of students in the College of (Computers and Information - Science) in favor of students in the College of Science. There are no differences between students' mean scores between the rest of the colleges and each other.

- Regarding the fifth principle: (using safe solvents): There are differences between average scores in the College of Medicine and Engineering in favor of students in the College of Engineering. There are also differences between the average grades of students in the College of Medicine - Computers and Information in favor of students in the College of Computers and Information. There are no differences between the average grades of students mean scores between the rest of the colleges and each other.

- The sixth principle (Design for energy efficiency): There are differences between students' mean scores in the College of Medicine and Science in favor of students in the College of Science. And there are no differences between the average grades of `students' mean scores between the rest of the colleges and each other. The eighth principle (avoid using derivatives: Reduce derivatives): There are differences between students' mean scores in the College of (Medicine - Science) in favor of students in the College of Science. There are no differences between students' mean scores between the rest of the colleges and each other. The ninth principle (use of catalysis), there are differences between students' mean scores in the Colleges of (Medicine and Engineering) in favor of students in the College of Medicine. There are no differences between students' mean scores among the rest of the colleges.

From the results, the level of awareness among science students at the University of Bisha about the principles and applications of green chemistry is very low. The students obtained an average of (4.036) on the total score of the scale, which amounted to (12) points, with a percentage of (33.63%). There are no differences between students' mean scores between the rest of the colleges and each other. There are also statistically significant differences at the significance level (0.01) between students average scores on the scale in the principles (fourth, fifth, sixth, and ninth). There were statistically significant differences at the significance level (0.05) between students' mean scores on the scale for the eighth principle only. There are

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no statistically significant differences at the significance level (0.05) between the students average scores on the scale as a whole, as well as on the (first - second - third - seventh - tenth - eleventh - twelfth) principles. These results are partially consistent with many results of previous studies, including the studies of Abdul Rahman (2005), Al-Amri (2008), Ghanem (2015), Nawar (2015), Saleh (2016), Muhammad (2020), and Jad Al-Haq (2018). These studies indicated weakness and a decline in the skills of chemical enlightenment and chemical innovations.

Table 7. The proposed scenario (principles and applications of green chemistry) for the preparatory year in the scientific colleges at the University of Bisha.

Academic level	Proposed course	Unit topics and applications in light of the principles	Course content principles	Number of lectures
Preparatory level	Principles and applications of green chemistry	Green chemistry and its philosophy Objectives and importance of green chemistry and its principles. Fields and applications of green chemistry. The economic benefits of green chemistry. The development of countries and sustainable development	Prevention	2
		Atom economics and its definitions. Applications of atom economic interactions. Green solvents and their role in developing the concept of supercritical fluids.	Atom economy	2
		Ionic liquids and their relationship to green chemistry.	synthesis less hazardous chemical	2
		Green energy and its many types. Biotechnology and its various technologies	Designing safer chemicals	2
		Hydrogen is the fuel of the future for countries	Safer solvents using	2
		Green stimuli and their various importance	Design for energy efficiency	2
		Bioenzymes and their role in development	Use of renewable feed stocks	2
		Bioreactors and their relationship to development	Reduce derivatives	2
		Green chemistry and preventing environmental pollution of all kinds	use of catalysis	
		Bio-green starters. The concept of waste, its types, and methods of treating it. Recycling different types of waste and its relationship to green chemistry. Sanitary	Design for degradation	2

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		landfills for waste. The polymer revolution and its importance in sustainable development. Different methods for decomposing chemical compounds. Microwave chemistry and its importance. Ultrasound technology.		
		Clean oxidation chemistry. Microscale forms and their relationship to the specialty intended by miniscale technology. Miniscale forms. Conducting scientific experiments using microscale technology. Conducting scientific experiments using miniscale technology.	Real-time analysis for pollution prevention	2
		Apply appropriate methods in transporting and using chemicals	Accident prevention chemistry	2
Total				24

Recommendations of the study:

The study recommended the following:

- Producing periodic publications on linking green chemistry applications to scientific subjects at various levels in the university colleges.

- Providing ongoing workshops for the teaching staff in scientific colleges on the foundations of applying the principles of green chemistry.

- Providing the teaching staff with training courses on including the principles and applications of green chemistry in the content of some chemistry courses.

Suggestions of the study:

In light of the results the study suggested the following:

- Designing an electronic learning environment based on the principles of green chemistry to develop environmental responsibility and sustainable development among students of scientific colleges.

- A proposed unit in green chemistry to develop analytical thinking and decision-making skills among medical college students.

- A proposed training program based on the principles of green chemistry to develop the levels of chemical knowledge and critical thinking among students of the College of Science.

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References

Al-Shami, Sahar Ibrahim (2018). A professional development program for secondary school chemistry teachers based on green chemistry and its impact on developing problem-solving skills and understanding environmental concepts. Unpublished doctoral dissertation, Faculty of Education, Ain Shams University.

Al-Mahmoudi, Muhammad. (2019). Scientific research methods (3rd ed.). National Library.

Salem, Amal Ali (2013). The effectiveness of a proposed unit in green chemistry in developing positive concepts and attitudes for second-year students in specialized secondary school in Libya. Unpublished master's thesis, Institute of Environmental Studies and Research, Ain Shams University.

Suleiman, Fawqia Rajab Abdel Aziz (2020). A proposed unit in light of sustainable development and the green economy to provide students of the science divisions at the College of Education with some concepts related to the green economy and sustainable trends, Journal of Educational and Psychological Studies, College of Education in Zagazig, Issue (109), pp. 1-47.

Saleh, Mai Muhammad (2016). A proposed curriculum in chemistry for the secondary stage in light of the concept of urban chemistry and its impact on developing awareness and making environmental decisions. Unpublished doctoral dissertation, Faculty of Education, Zagazig University.

Nahari, Laila Muhammad (2009). Green chemical techniques in organic preparations: self-condensation of enamines under acidic conditions by environmentally friendly methods. Unpublished master's thesis, College of Education for Girls, King Abdulaziz University, Kingdom of Saudi Arabia.

Abu Al-Wafa, Rabab Ahmed (2018). The effectiveness of a proposed green chemistry course based on the principles of Education for Sustainable Development (ESD) in developing chemical culture among student teachers in the Chemistry Division. Journal of Scientific Education.21(2), 1-51.

Al-Sarihi, Hassan Awad, and others: Scientific thinking and research, Jeddah, Scientific Publishing Center, King Abdulaziz University, 2008.

Al-Sayed, Suzan Muhammad (2007). The effectiveness of a proposed program in environmental education supported by enrichment activities in providing primary education students with some environmental concepts and the ability to make decisions regarding some environmental issues. Journal of Scientific Education, 10(1), 55-109.

Al-Shuaili, Ali and Al-Rabani, Ahmed (2010). The level of awareness of climate change among student teachers in the sciences and social studies major at the College of Education at Sultan Qaboos University, Jordanian Journal of Educational Sciences, 6(4), 284-269.

Al-Omari, Aziz (2008). The level of environmental culture among science teachers at the primary stage in the city of Tabuk, unpublished master's thesis, College of Education. Umm Al-Qura University, Mecca, Saudi Arabia.

Al-Ayasrah, Ahmed Hassan (2017). The level of environmental awareness of the phenomenon of global warming among science teachers in the primary stage and its relationship to some variables, Al-Balqa Journal of Research and Studies, Volume (20), Issue (20), 33-48.

Jad Al-Haqq, Nahla Abdel Muti Al-Sadiq. (2018). A program in chemical innovations to develop chemical enlightenment among student teachers at the College of Education, Journal of Scientific Education, Egypt, 21 (10), 109-130.

Haggag Aya Ahmed Abdel Fattah (2020). Developing a program to prepare chemistry teachers in colleges of education in light of the principles of green chemistry and its applications, unpublished doctoral dissertation, College of Education, Benha University.

Salem, Amal Ali (2013). The effectiveness of a proposed unit in green chemistry in developing positive concepts and attitudes for second-year students in specialized secondary school in Libya. Unpublished master's thesis, Institute of Environmental Studies and Research, Ain Shams University.

Shaker, Imad Sabry (2009). Green chemistry. Cairo: Arab House for Publishing and Distribution.

Shaker, Imad Sabry (2009). Green chemistry. Cairo: Arab House for Publishing and Distribution.

Abdel Fattah, Aladdin Abdel Aziz (2003). Developing advanced agricultural secondary school curricula in light of environmental dimensions. Unpublished doctoral thesis, Faculty of Education in Benha, Zagazig University.

- Ghanem, Tafida Sayed (2015). A proposed unit in green technology based on the technological design process and its effectiveness in developing technological model design and decision-making skills in the environmental sciences course for third-year secondary school students. Journal of Scientific Education, 18(1), 1-44.

- Nabhan, Yahya Ismail. (1430). Scientific research methods between theory and application, Amman: Jaffa Scientific Publishing and Distribution House. - Nawar, Iman Abdel Hamid (2015). A proposed program based on self-learning to develop concepts of chemical innovations and decision-making skills among students of science clubs at the secondary stage. Unpublished doctoral thesis, Institute of Educational Studies, Cairo University.

Muhammad, Karima Abdullah Mahmoud (2020) A proposed curriculum in science based on the principles of green chemistry and its applications to develop awareness of environmental sustainability and positive thinking among middle school students, Journal of the College of Education (Ain Shams University), Issue Forty-Four, Part Four, pp. 209-314.

Al-Azab, Iman Saber Abdel Qader (2020). The effectiveness of a proposed unit in green technology to capture concepts and develop awareness of them, Scientific Creation Pioneers MAGAZiNE, TwELVEth EDiTion (SCP), PP264-311

Abdel Rahman, Saad (2003): Psychological measurement (theory and application). Cairo: Dar Al-Fikr Al-Arabi.

Abdul Rahman, Abdullah Ahmed (2005). Evaluating chemistry curricula at the secondary level in light of developments in chemistry and its ethics. Unpublished master's thesis, Faculty of Education in Damietta, Mansoura University.

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DOI: https://doi.org/10.62754/joe.v3i4.356810.62754

Abdul Moez, Muhammad Samir (2007). Green chemistry. Cairo: Dar Al-Kutub.

Ul-Haq, J., Mushtaq, S., Visas, H., & Hye, Q. M. A. (2023). Does economic stress matter for the rising divorce rate in China? A provincial perspective. Nurture, 17(1), 18–28. https://doi.org/10.55951/nurture.v17i1.142

Abdul Wahab, Fatima Muhammad (2011). A proposed program for electronic waste using interactive hypermedia to develop knowledge about it, decision-making regarding it, and self-motivation for learning among first-year secondary school students. Journal of Scientific Education, 14(2), 63-110.

Assaf, Saleh Hamad. (1427). Introduction to Research in Behavioral Sciences, 4th edition, Riyadh: Obeikan.

Nahari, Laila Muhammad (2009). Green chemical techniques in organic preparations: self-condensation of enamines under acidic conditions by environmentally friendly methods. Unpublished master's thesis, College of Education for Girls, King Abdulaziz University, Kingdom of Saudi Arabia.

Second: Foreign references

Ablan, C. (2006). Green chemistry and the role of carbon dioxide as a solver in catalysis. Unpublished doctoral dissertation, University of Hawaii, Manoa.

Abu Al-Wafa, Rabab Ahmed (2018) The effectiveness of a proposed green chemistry course based on the principles of education for sustainable development in developing chemical culture among student teachers, Chemistry Division, Journal of Scientific Education, Egyptian Society for Scientific Education 21 (2) 1-51

Ahuja, S. (2013). Green Chemistry and Other Novel Solutions to Water Pollution: Overview. Washington American Chemical Society, In book: Novel Solutions to Water Pollution (pp.1-14) DOI:10.1021/bk-2013-1123.ch001

Ameta, K. Dandia, A. (2014). Green Chemistry: Synthesis of Bioactive Heterocycles. India: Springer Science Business Media

Anastas, P & Beach, E. (2009) Green Chemistry Education, American Chemical Society, Washington, 22 April

Anastas, P. & Warner, J. (1998). Green chemistry: theory and practice. New York: Oxford University Press.

Beyene, Y. (2009). Environmental problems and solutions in Ethiopia generally and in Africa specifically (A case study on Ethiopia). Unpublished master dissertation, Jimma University, Ethiopia, Addis Ababa.

Cacciatore, K. (2010). Development and assessment of green research-based instructional materials for the general chemistry laboratory. Unpublished doctoral dissertation, University of Massachusetts Boston.

Cullipher, S. (2015). Research for the advancement of green chemistry practice: studies in atmospheric and educational chemistry. unpublished doctoral dissertation, University of Massachusetts Boston.

Dodson, J., Summerton, L., Hunt, A. & Clark, J. (2014). Green Chemistry Education at the University of York: 15 years of experience. Educación químicađ, 24, 27-35.

Fawzy, M. (2012). Synthesis of some heterocyclic compounds with Expected Biological activity using some Green Chemistry tools. Unpublished doctoral dissertation, Faculty of Science, Menoufia University.

Gross, E. (2013). Green chemistry and sustainability: An undergraduate course for science and non-science majors. Journal of chemical education, 90 (4), 429-431.

Habibi, L., Sabbaghanb, M. & Mohammad, S. (2013). A Comparative Study in Green Chemistry Education Curriculum in America and China. 6th International Conference on University Learning and Teaching, Procedia - Social and Behavioral Sciences, 288 – 292.

Hamidah, N., Zamhari, M. & Eilks, I. (2018). A project of incorporating the principles of green chemistry into first year general chemistry education in Indonesia. Building bridges across disciplines, 197-202.

Karpudewan, M., Ismail, Z. & Mohamed, N. (2011). Green Chemistry: Educating Perspective Science Teachers in Education for Sustainable Development at School of Educational Studies, USM. Journal of Social Sciences, 7 (1), 42-50.

Karpudewan, M., Roth, W. & Ismail, Z. (2015). Education in Green Chemistry: Incorporating Green Chemistry into Chemistry Teaching Methods Courses at the Universiti Sains Malaysia. Canada: Royal society of chemistry

Miller, T. (2012). A context based approach using green chemistry / Bio-remediation principles to enhance interest and learning of organic chemistry in a high school ap chemistry classroom. unpublished master dissertation, Michigan State University, U.S.A.

Pérez, R. & Escandar, G. (2016). Experimental and chemometric strategies for the development of Green Analytical Chemistry (GAC) spectroscopic methods for the determination of organic pollutants in natural waters. Sustainable Chemistry and Pharmacy 4 , 1–12

Third: International, Arab and local conferences that focused on the principles of green chemistry and its applications:

The nineteenth conference entitled "Green Chemistry and Sustainable Industrial Development," which was held at the Ministry of Environment in Cairo, available at: http://www.vetogate.com/2925880

The fifth conference entitled "Chemistry for a Better Future" organized by the Kuwait Chemical Society in the State of Kuwait available at: http://www.alkuwaityah.com/Article.aspx?id=45812

The Second International Conference entitled "Green Chemistry and Engineering" in Spain https://scientificfederation.com/green-chemistry-2018/

The 5th Green Chemistry and Sustainable Engineering Conference available at: https://www.elsevier.com/events/conferences/green-and-sustainable-chemistry-conference

The third international scientific conference entitled "Science for Life", which was held in Hurghada, Egypt, available at: http://www.asu.edu.eg/ar/130/event

Umm Al-Qura University project in the Kingdom of Saudi Arabia available at: https://uqu.edu.sa/chmscimm/5424

King Abdulaziz University Project in the Kingdom of Saudi Arabia https://gce-sgcg.njb.kau.edu.sa/Content-363800-AR-251420