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| RESEARCH ARTICLE

Green Chemistry and Organic Solvent Safety Awareness among Chemistry Students

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| ABSTRACT

This study investigated chemistry and chemistry-related students' self-reported awareness about green chemistry principles, hazards of organic solvents, safe laboratory practices, management of chemical waste, and the students' perception of barriers in practicing green chemistry in educational laboratory settings. A descriptive cross-sectional survey design was used, and data were collected using a structured Arabic questionnaire that was sent electronically through Google Forms. A total of 182 valid responses were received from undergraduate students enrolled in a chemistry or related scientific program. The questionnaire consisted of demographic and academic questions, 31 Likert-scale questions and one open-ended question. Responses were scored on a 5-point Likert scale (1 = Strongly Agree; 5 = Strongly Disagree), with lower mean scores reflecting higher levels of agreement. For the awareness domains, lower mean scores reflected higher self-reported awareness. The barriers and challenges domain was understood separately, with lower scores reflecting greater perceived barriers and challenges. Descriptive statistics, Cronbach's alpha, independent-samples t-test, one-way ANOVA, Pearson correlation and thematic summary of open-ended responses were used. The Cronbach's alpha coefficients of the questionnaire were in the range of 0.858–0.934 for the awareness domains, and 0.963 for the overall awareness scale, excluding barriers. The overall awareness scale showed strong self-reported agreement, with a mean score of 1.494. Safe laboratory practices showed the strongest self-reported awareness, while green chemistry awareness was comparatively weaker. Students' self-reported capability in differentiating between relatively safer solvents and highly hazardous solvents was the weakest item-level result. However, students who had completed an organic chemistry course, an organic chemistry laboratory, or three or more chemistry laboratories reported significantly greater self-reported awareness. The overall awareness score was comparable between gender and academic level and not significantly associated with gender or academic level. Students also perceived several barriers, including the lack of chemical waste containers, limited practical training, and the need for additional workshops. These findings should be interpreted as students' perceived awareness rather than direct evidence of actual knowledge or observed laboratory practice. The results indicate that students reported high perceived awareness of laboratory safety and green chemistry; however, emphasis is needed in practice on safer solvents, using SDS/MSDS, how to interpret the labels on the chemicals used and what to do with chemical waste.

| KEYWORDS

Green chemistry education; awareness of safety in organic solvents; laboratory safety awareness; self-reported awareness; chemistry students; chemical waste management.

| ARTICLE INFORMATION

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1. Introduction

Green chemistry provides a way of designing chemical work so that hazardous substances and waste are reduced as much as possible (Anastas & Warner, 1998). The 12 principles proposed by Anastas and Warner place attention on prevention, efficient use of materials, safer reactions and solvents, lower energy demand, and accident prevention (American Chemical Society, n.d.). In undergraduate chemistry education, these ideas are useful because they connect chemical content with human health, environmental effects, safety, sustainability, and responsible decisions in the laboratory (Aubrecht et al., 2019). They also help students link structure and reactivity with the possible health and environmental consequences of chemicals and chemical processes (Aubrecht et al., 2019).

Green chemistry and laboratory safety can be integrated into courses as they both have students identify hazards, minimize risk, and think about safer alternatives prior to engaging in chemical activities (O'Neil et al., 2020). A systems-thinking perspective can benefit this process by having students consider the safety and sustainability aspects of experiments prior to and during experimentation in order to prevent problems after experimentation occurs (O'Neil et al., 2020). This is particularly true in organic chemistry lab settings, where safer and greener alternatives to standard undergraduate experiments can decrease hazards and waste and still maintain the educational value of the experiment (Beyond Benign & My Green Lab, 2020). For example, when choosing and applying organic solvents, their selection and use go hand in hand with green chemistry and laboratory safety (Beyond Benign & My Green Lab, 2020).

Organic solvents are significant in the teaching laboratory but can pose multiple hazards depending on the solvent, type of exposure, concentration and working conditions. Potential hazards include flammability, inhalation and skin contact, neurological toxicity, reproductive toxicity, and carcinogenicity (National Institute for Occupational Safety and Health, 2018; Occupational Safety and Health Administration, n.d.). The general guidance for laboratory safety reminds us that chemical hazards must be identified before work starts and that exposure can be limited by using safer chemicals or procedures, engineering controls, good work habits and PPE (National Research Council, 2011). Safety Data Sheets (SDS) and hazard labels are therefore primary sources of information as they provide a description of hazards, protective measures, safe handling, storage and emergency precautions (Occupational Safety and Health Administration, 2012). Students should be familiar with SDS/MSDS, labels, use of fume hoods, personal protective equipment (PPE), safer solvents, and waste segregation as part of safe and sustainable laboratory practice (National Research Council, 2011; Occupational Safety and Health Administration, 2012).

Many studies have already been conducted on university and chemistry students to explore awareness of and practices related to laboratory safety (Sonawane et al., 2023; Wu et al., 2023). The results of these studies indicate that safety awareness is still a concern in chemistry education, but the results of surveys should be interpreted with caution since they rely on the self-reported knowledge, behavior or laboratory practice of the participants (Miller, 2012). Social desirability bias can also impact self-report data in higher education contexts, especially when questions involve behaviours that students are aware of as being expected or socially acceptable, such as safety and responsibility in the laboratory (Miller, 2012; Lavidas et al., 2022). For this reason, the present study does not claim to measure actual knowledge or observed laboratory behavior, but rather uses the terms self-reported awareness, perceived awareness and students' perceptions.

The present study examines students' self-reported awareness of green chemistry principles, organic solvent hazards, safe laboratory practices, and chemical waste management. It also explores the barriers that students perceive when trying to apply green chemistry and safe laboratory practice in educational laboratories. The study is intended to provide evidence that may support improvements in laboratory safety education, SDS/MSDS instruction, hazard communication, safer solvent selection, and chemical waste-management teaching.

2. Literature Review

2.1 The Concept of Green Chemistry in Chemistry Teaching

In chemistry education, green chemistry can be used to bridge the gap between chemistry learning and the concepts of reducing hazards, safety, sustainability, and environmental responsibility (Anastas & Warner, 1998; Aubrecht et al., 2019). The 12 principles are helpful when teaching design since they illustrate how decisions in chemical design can decrease waste, eliminate hazardous materials, use energy more effectively, and use safer solvents and auxiliaries (American Chemical Society, n.d.; Anastas & Warner, 1998). Aubrecht et al. (2019) suggested that green chemistry materials can be used to help students learn about systems thinking, safety concerns, and sustainability-related thinking. In this context, systems thinking could enable more students to think beyond the immediate effects of a chemical reaction and take into account the broader environmental and social impacts of chemicals throughout their life cycles (Aubrecht et al., 2019; Paschalidou et al., 2022).

As outlined in the scoping review of Paschalidou et al. (2022), the application of systems thinking in green chemistry education has been reported as a way to establish a connection between chemistry at the molecular level and environmental and sustainability issues. This link is important for undergraduates in the lab, as they decide on procedures, hazards, materials, waste, and environmental impact in their practical work (Aubrecht et al., 2019; O'Neil et al., 2020). Therefore, green chemistry education is an appropriate background for studying students' self-reported knowledge of green chemistry principles, safety of organic solvents, and chemical waste management. Another recent study on the training of green and sustainable chemistry at tertiary levels also pointed out the importance of laboratory learning and the need to assess students' competencies in green chemistry (Gunbatar et al., 2025).

2.2 Laboratory Safety Awareness in Chemistry Education

Laboratory safety is an integral component of chemistry instruction as students must recognize hazards, assess risk, and implement appropriate controls prior to and during chemical laboratory experiences (National Research Council, 2011). Good laboratory practice involves hazard assessment, chemical management, proper storage, waste disposal planning, engineering controls, proper work practices and PPE (National Research Council, 2011). O'Neil et al. (2020) linked green chemistry with lab safety and proposed a shift in laboratory culture from reacting to complying with a proactive approach to risk assessment. In undergraduate laboratories, it is important that the student not only be aware of the rules but also understand the importance of certain chemical hazards, controls, and safer alternatives (O'Neil et al., 2020; National Research Council, 2011).

Student safety awareness has also been examined through survey-based research in chemistry education (Sonawane et al., 2023; Wu et al., 2023). Sonawane et al. (2023) used an online chemical safety survey that included laboratory safety, safety symbols, and waste-disposal questions. Wu et al. (2023) conducted a cross-sectional survey of 335 university students and examined GHS pictograms, attitudes toward laboratory safety, safety practices, emergency equipment, and emergency procedures.

Wu et al. (2023) reported weaknesses in students' laboratory safety awareness, especially in recognizing GHS pictograms and dealing with laboratory emergencies. Such findings support the need to study students' self-reported awareness of laboratory safety in chemistry and chemistry-related educational contexts (Sonawane et al., 2023; Wu et al., 2023).

2.3 Organic Solvents and Safer Alternatives

Organic chemistry laboratories are a suitable setting for examining organic solvent safety because many undergraduate organic experiments involve solvents and generate waste. Green chemistry resources for undergraduate organic chemistry laboratories show that experiments can remain rigorous while reducing hazards and waste (Beyond Benign & My Green Lab, 2020). Organic solvents may create health and safety concerns depending on the solvent and how it is handled, including inhalation exposure, skin exposure, neurotoxicity, reproductive toxicity, carcinogenicity, and flammability (National Institute for Occupational Safety and Health, 2018; Occupational Safety and Health Administration, n.d.). Solvent selection therefore provides a practical point where green chemistry and laboratory safety meet, as different solvents present different environmental, health, and safety profiles (Byrne et al., 2016; Beyond Benign & My Green Lab, 2020).

Byrne et al. (2016) provided a review of solvent-selection guides and an explanation of how these tools can be used to compare solvents and minimize use of more hazardous chemicals in chemical processes. This type of guide can aid in making greener and safer choices by including considerations about the environment, health, safety and practical aspects (Byrne et al., 2016). Learning the hazards of solvents is more specific than learning safety; it requires students to analyze alternatives and to make safer decisions (Beyond Benign & My Green Lab, 2020; Byrne et al., 2016). This is why it is relevant to a study on green chemistry and organic solvent safety awareness that students correctly report their ability to distinguish relatively safer solvents from highly hazardous solvents (Byrne et al., 2016; National Institute for Occupational Safety and Health, 2018).

2.4 SDS/MSDS and Hazard Labels

Before students use any chemical in a chemistry laboratory, they must be provided with information that provides clarity on chemical hazards, controls for exposure to those hazards, how to store, handle, and use the chemicals, and how to respond to an emergency (Occupational Safety and Health Administration, 2012; National Research Council, 2011). Safety Data Sheets are standardized documents providing information on chemical properties, physical and health hazards, environmental hazards, protective measures and safe handling, storage and transfer (Occupational Safety and Health Administration, 2012). SDS/MSDS and hazard labels can aid in these safer laboratory decision-making actions, such as risk identification and selection of appropriate precautions prior to using or handling a chemical (Occupational Safety and Health Administration, 2012; National Research Council, 2011). In teaching laboratories, these tools are directly linked to students' knowledge of chemical hazard communication and safe handling.

Wu et al. (2023) identified recognition of GHS pictograms as a weak area in a laboratory safety awareness survey. This finding suggests that hazard communication tools should be taught explicitly during laboratory safety training rather than being treated as information students will learn incidentally (Wu et al., 2023; Occupational Safety and Health Administration, 2012). Accordingly, students' awareness of SDS/MSDS, warning labels, fume hoods, and PPE is closely connected with their perceived preparation for safe work with organic solvents (National Research Council, 2011; Occupational Safety and Health Administration, 2012).

2.5 Chemical Waste Management in Teaching Laboratories

Chemical waste management is an essential part of safe laboratory work because improperly managed laboratory waste can create chemical hazards and environmental problems (National Research Council, 2011). The National Research Council

emphasizes managing laboratory waste from purchase through use in ways that protect safety and reduce environmental impact (National Research Council, 2011). It also recommends preparing hazardous and nonhazardous waste-disposal plans before laboratory activities begin (National Research Council, 2011). In this context, waste prevention and source reduction are preferred because the safest waste is the waste that is not produced in the first place (National Research Council, 2011).
Common waste-reduction approaches include using smaller-scale operations, reducing waste produced during procedures, and choosing less hazardous or nonhazardous chemicals when possible (National Research Council, 2011). Waste must also be identified and labelled correctly because proper disposal depends on knowing the characteristics of the waste material (National Research Council, 2011). In chemistry education, de Oliveira et al. (2021) reported that a short training activity helped undergraduate students develop concepts, procedures, and attitudes related to chemical waste management in experimental classes.

The training described by de Oliveira et al. (2021) included separation and storage of residues, treatment and disposal processes, and the environmental, social, and economic implications of waste management. These findings support including chemical waste management as a domain when examining students' self-reported awareness of green chemistry and laboratory safety (National Research Council, 2011; de Oliveira et al., 2021).

2.6 Perceived Barriers to Green Chemistry and Laboratory Safety
In educational laboratories, applying green chemistry and laboratory safety is not only a matter of what students know. It may also depend on curriculum design, instructor support, laboratory training, and institutional practices (Aubrecht et al., 2019; O'Neil et al., 2020). Aubrecht et al. (2019) noted that resources for teaching green chemistry are becoming more available, but practical models that support systems thinking still need development and testing in classrooms and laboratories. Hutchison (2019) also described curricular change as slow and challenging because chemistry curricula and institutions are complex and may contain several barriers to implementation. Similarly, O'Neil et al. (2020) argued that a proactive safety culture requires thinking about safety as more than rule compliance and treating it as part of a systems perspective.

Training is also important in chemical waste education. de Oliveira et al. (2021) emphasized that instruction can improve students' understanding of waste-management procedures and related attitudes. On this basis, students' perceptions of training, curriculum integration, waste-management procedures, and safety culture are relevant issues to explore in studies of green chemistry and laboratory safety education (Aubrecht et al., 2019; O'Neil et al., 2020; de Oliveira et al., 2021).

2.7 Self-Reported Awareness and Survey-Based Research
Surveys are commonly used to explore students' perceptions, attitudes, and self-reported knowledge in educational research (Miller, 2012; Lavidas et al., 2022). However, self-report surveys should be interpreted carefully because students may report what they believe, remember, or consider socially acceptable rather than what they actually do in the classroom or laboratory (Miller, 2012). Miller (2012) discussed social desirability bias in student self-report surveys and noted that such surveys are widely used in higher education. Lavidas et al. (2022) also showed that the setting in which a survey is administered can affect the sensitivity of students' responses.

Thus, questionnaire information should not be considered as actual knowledge and observed behaviour. The results in the current study are assumed to reflect students' self-reported awareness and perceptions, corresponding to the cross-sectional survey design (Miller, 2012; Lavidas et al., 2022).

2.8 Research Gap and Rationale of the Present Study
There are previous studies related to green chemistry education, awareness of lab safety, use of safer solvents, chemical waste management, and the challenges of self-report survey research (Aubrecht et al., 2019; O'Neil et al., 2020; Byrne et al., 2016; de Oliveira et al., 2021; Miller, 2012; Gunbatar et al., 2025). The present study combines these areas into one questionnaire that covers both awareness domains and perceived barriers of chemistry and chemistry-related students (Aubrecht et al., 2019; O'Neil et al., 2020; Sonawane et al., 2023; Wu et al., 2023; de Oliveira et al., 2021). This dual focus is valuable because the issues of solvent hazards, safer solvent selection, waste separation, use of SDS/MSDS, and lab safety practice are interrelated components of the safe and sustainable chemistry education continuum (Aubrecht et al., 2019; O'Neil et al., 2020; National Research Council, 2011).

Thus, the present research contributes to chemistry education research by focusing on areas linked to chemistry and chemistry-related students using a cross-sectional survey method with a self-report approach. Since the study depends on self-reported responses, the findings are interpreted as what students perceive and report rather than as direct measures of what they actually know or observe in the laboratory (Miller, 2012; Lavidas et al., 2022).

3. Methodology

3.1 Study Design

This study used a descriptive cross-sectional survey design. This design was deemed suitable as the study sought to gather data on students' self-reported awareness and perceptions of the principles of green chemistry, hazards of organic solvents, safe laboratory practices, chemical waste management and perceived barriers in educational laboratory settings at a single point in time.

3.2 Study Population

The study participants were students in undergraduate chemistry and chemistry-related majors. These programmes encompassed Chemistry, Applied Chemistry, Biochemistry, Pharmacy and other disciplines in the field of science. The target population for the study were students who have taken at least one chemistry course and/or chemistry lab because they were believed to have enough academic or laboratory background to answer the items of the questionnaire.

3.3 Study Sample

182 valid responses were used in the final statistical analysis. The final sample consisted of students attending chemistry and chemistry-related courses and who voluntarily agreed to participate in the study and completed the questionnaire. The responses in the analysis were all those that met the study's eligibility criteria.

3.4 Inclusion and Exclusion Criteria

Students were selected for participation if they were undergraduate students and enrolled in chemistry or chemistry-related courses and had taken at least one chemistry course or chemistry laboratory. Only students who were willing to be involved in the study were included.

If the participants did not consent, provided incomplete responses or did not meet the inclusion criteria, these answers were not taken into account. None of the responses were omitted from the final data set following data screening and the final sample size was n = 182.

3.5 Sampling Technique

A convenience and snowball sampling technique was used. The questionnaire was sent to accessible groups of students via Google Forms. Further, the survey link was provided to relevant students by academics in the classes and among student groups. The sampling method was appropriate for the context of the study and for accessing students in chemistry and related science programs.

3.6 Data Collection Tool

The data were collected using a structured questionnaire that was designed in Arabic to ensure clear communication and mutual understanding among the participants. The choice of Arabic was made since it is the target students' native language. The Arabic questionnaire was translated into English for reporting purposes, and the translated version was reviewed to ensure conceptual equivalence with the original Arabic items.

The questionnaire started with a short introduction to the project, where the objective of the project was explained and that participation was voluntary, and that the information would only be used for research. Participants were asked first to indicate their consent to participate before arriving at the items in the questionnaire. Those who agreed went on to the rest of the sections.

The following sections were included in the questionnaire:

1. Demographic and academic information.
2. Green chemistry awareness, 6 items
3. Organic Solvent Hazard Awareness, 6 items
4. Safe laboratory practices awareness, 7 items
5. Chemical waste management awareness, 5 items
6. Perceived barriers and challenges, 7 items
7. One optional open-ended question.

3.7 Questionnaire Scale and Coding

The items for awareness and barriers were rated on a five-point Likert scale from Strongly Agree to Strongly Disagree. The following coding was used for responses:

Table 1. Likert Scale Coding

Response	Code
Strongly Agree	1
Agree	2
Neutral	3
Disagree	4
Strongly Disagree	5

Thus, the lower the mean score, the greater the agreement. For positively worded awareness items, lower mean scores represent higher self-reported awareness. The barriers and challenges domain was interpreted separately because agreement with the barrier items reflects greater perception of barriers as opposed to greater awareness. Although Likert-scale responses are ordinal, mean scores were used as descriptive indicators of response tendency alongside medians and percentage distributions.

Since the items for awareness were positively worded and coded the same direction, no reverse coding was done. The overall awareness score was obtained from only 24 awareness items and the barriers and challenges domain was not counted as a part of this overall score.

3.8 Data Cleaning and Data Quality Control

The data set from Google Forms was screened prior to statistical analysis. There was informed consent of all those who were included in the dataset. There was no missing data in the closed-ended demographic or Likert scale items. The available structure of the data set did not yield any clearly duplicated responses.

The blank columns created during the export process were blanked out prior to analysis. The timestamp column was not used in the statistical analysis. The open item was analysed thematically, but not used in the quantitative scale scores.

There were 182 valid responses in the final cleaned data set.

3.9 Validity and Reliability

3.9.1 Content Validity

Academic experts on chemistry, laboratory safety, and research methodology reviewed the questionnaire to check the clarity, relevance, and suitability of the items for the aims of the study. The items were modified as a result of the reviewers' comments prior to the questionnaire's distribution.

No factor analysis was conducted; therefore, the domain structure was based on theoretical relevance, expert review, and internal consistency reliability.

3.9.2 Reliability

Cronbach's alpha was calculated for each domain of the questionnaires and for the total awareness scale to measure internal consistency reliability. The overall awareness scale was made up of the 24 awareness items, excluding the barriers and challenges domain, as the agreement of the barrier items is a measure of perceived barriers and not of increased awareness. The optional open-ended question was not included in the reliability analysis.

Table 2. Reliability of Questionnaire Domains

Domain	Number of Items	Cronbach's Alpha
Green chemistry awareness	6	0.858
Organic solvent hazard awareness	6	0.894
Safe laboratory practices awareness	7	0.934
Chemical waste management awareness	5	0.870
Barriers and challenges	7	0.890
Overall awareness scale, excluding barriers and open-ended item	24	0.963

The Cronbach's alpha values were within the good to excellent range for the domains of the questionnaire. These values indicate strong internal consistency, although the high overall alpha may also reflect conceptual overlap among some awareness items. The findings of reliability indicate that the questionnaire domains can be used to analyze the self-reported student awareness and perceptions.

3.10 Statistical Analysis

Data were subjected to statistical procedures appropriate for cross-sectional survey data. Demographic and academic variables were summarized using descriptive statistics (frequencies and percentages). For the Likert-scale items and questionnaire domains, means, standard deviations, medians, modes, frequencies and percentages were calculated.

The internal consistency reliability was assessed by Cronbach's alpha. The independent-samples t-test was used to compare the mean score of awareness of two groups, male and female students, students who had studied an organic chemistry course and those who had not, and students who had studied an organic chemistry laboratory and students who had not. Welch's t-test was used because it is appropriate for unequal-sized groups.

The differences in awareness scores between academic levels were analyzed using one-way ANOVA. When the sizes of the subgroups were very small, categories were aggregated, where appropriate, to make for more stable comparisons. For instance, the number of chemistry laboratories completed was dichotomized into students who finished < 3 chemistry laboratories and students who finished ≥ 3 chemistry labs.

Pearson correlation analysis was conducted to explore the relationships between the domains of the questionnaire. Positive correlations between the awareness domains suggest that students who indicated a stronger agreement in a given domain tended to indicate a stronger agreement in other domains, given that 1 = Strongly Agree, and 5 = Strongly Disagree.

The optional write-in answers were summarized thematically. The responses were examined and categorized under general headings: Laboratory safety training, Green chemistry education, Selection of safer solvents, Management of chemical waste, Supervision, and Infrastructure of the laboratory. Responses to Q32 were read repeatedly and grouped into recurring themes. Similar responses were combined under broader thematic categories, and frequencies were calculated based on the dominant theme in each response.

Inferential analyses were carried out adopting a statistical significance level of $\alpha \leq 0.05$. Because the inferential comparisons were exploratory, results were interpreted using statistical significance together with the direction and magnitude of mean differences.

3.11 Ethical Considerations

Participation in the study was voluntary. All participants gave informed consent electronically prior to completing the questionnaire. It was explained to the participants that the data collected will be utilized for scientific research and that their answers will be kept confidential.

Participant names and e-mail addresses were not included in the data set used for analysis. Respondents were anonymised and analysed as a whole.

4. Results and Discussion

4.1 Data Screening and Demographic Characteristics

In the final analysis, 182 responses were received that were suitable for analysis. No missing answers were found within the closed-ended demographic and Likert items and all included participants consented to participate. There was a response scale ranging from 1 = Strongly Agree to 5 = Strongly Disagree, with lower scores representing stronger agreement. The awareness domains were interpreted inversely; that is, lower mean scores on the scales represent higher levels of self-reported awareness, with the barriers and challenges domain being interpreted separately as agreement on these items represents a stronger perception of barriers.

Table 3. Demographic and Academic Characteristics of Participants

Variable	Category	n	%
Gender	Male	64	35.2
Gender	Female	118	64.8
Academic level	Completed second year	37	20.3
Academic level	Will begin third year	30	16.5
Academic level	Third year	16	8.8
Academic level	Other	99	54.4
Specialization	Chemistry	156	85.7
Specialization	Applied Chemistry	10	5.5
Specialization	Pharmacy	4	2.2
Specialization	Biological Sciences	1	0.5
Specialization	Other	11	6.0
Studied organic chemistry course	Yes	139	76.4
Studied organic chemistry course	No	43	23.6
Studied organic chemistry laboratory	Yes	135	74.2
Studied organic chemistry laboratory	No	47	25.8
Number of chemistry laboratories completed	No laboratory completed	3	1.6
Number of chemistry laboratories completed	One laboratory	43	23.6
Number of chemistry laboratories completed	Two laboratories	8	4.4
Number of chemistry laboratories completed	Three laboratories or more	128	70.3

Most participants were female students. The majority of the respondents were chemistry students and the majority studied an organic chemistry course and organic chemistry laboratory. Most of the students also reported to complete three or more chemistry laboratory courses. This sample profile shows that a significant number of respondents may be exposed to academic or laboratory environments which could be of relevance to green chemistry and awareness of safety issues related to organic solvents.

4.2 Descriptive Statistics of Questionnaire Domains

Table 4. Descriptive Statistics of Questionnaire Domains

Domain	N	Mean	SD	Median	Minimum	Maximum
Green chemistry awareness	182	1.702	0.657	1.67	1.00	5.00
Organic solvent hazard awareness	182	1.499	0.651	1.33	1.00	5.00
Safe laboratory practices awareness	182	1.336	0.598	1.00	1.00	5.00
Chemical waste management awareness	182	1.458	0.600	1.20	1.00	4.80
Barriers and challenges	182	1.596	0.662	1.57	1.00	5.00
Overall awareness scale, excluding barriers	182	1.494	0.573	1.33	1.00	4.92

There was generally good agreement with the awareness statements with an overall awareness mean of 1.494. Safe laboratory practices awareness had the lowest domain mean, indicating the highest self-reported level of awareness in this domain. Green chemistry awareness had the highest mean and therefore reflected a relatively weaker level of agreement when compared with the other areas of awareness. The barriers and challenges domain also had some agreement, and this domain is a perceived barrier and not a level of awareness.

4.3 Item-Level Descriptive Results

Table 5. Item-Level Descriptive Statistics

Item	Domain	Mean	SD	Agree/Strongly Agree %	Neutral %	Disagree/Strongly Disagree %
Q1	Green chemistry awareness	1.473	0.662	95.6	2.7	1.6
Q2	Green chemistry awareness	1.566	0.796	91.2	6.0	2.7
Q3	Green chemistry awareness	1.621	0.863	88.5	7.1	4.4
Q4	Green chemistry awareness	1.467	0.832	91.8	5.5	2.7
Q5	Green chemistry awareness	1.813	0.878	78.6	19.2	2.2
Q6	Green chemistry awareness	2.275	1.068	61.5	24.7	13.7
Q7	Organic solvent hazard awareness	1.341	0.668	95.6	2.7	1.6
Q8	Organic solvent hazard awareness	1.533	0.791	91.8	5.5	2.7
Q9	Organic solvent hazard awareness	1.396	0.703	95.6	2.7	1.6
Q10	Organic solvent hazard awareness	1.412	0.713	95.1	3.3	1.6
Q11	Organic solvent hazard awareness	1.643	0.910	86.3	8.2	5.5
Q12	Organic solvent hazard awareness	1.670	0.992	84.1	9.9	6.0
Q13	Safe laboratory practices awareness	1.379	0.768	94.0	2.7	3.3
Q14	Safe laboratory practices awareness	1.357	0.757	94.5	2.2	3.3
Q15	Safe laboratory practices awareness	1.390	0.798	92.9	3.3	3.8
Q16	Safe laboratory practices awareness	1.291	0.671	96.2	2.2	1.6
Q17	Safe laboratory practices awareness	1.302	0.707	96.2	1.1	2.7
Q18	Safe laboratory practices awareness	1.302	0.596	95.6	3.8	0.5
Q19	Safe laboratory practices awareness	1.330	0.623	94.5	4.9	0.5
Q20	Chemical waste management awareness	1.440	0.768	93.4	3.8	2.7
Q21	Chemical waste management awareness	1.330	0.605	95.6	3.8	0.5
Q22	Chemical waste management awareness	1.456	0.725	91.2	7.1	1.6
Q23	Chemical waste management awareness	1.390	0.678	95.6	2.7	1.6
Q24	Chemical waste management awareness	1.676	0.892	83.5	12.1	4.4
Q25	Barriers and challenges	1.484	0.799	91.8	6.0	2.2
Q26	Barriers and challenges	1.692	0.907	86.3	8.8	4.9
Q27	Barriers and challenges	1.654	0.967	83.5	10.4	6.0
Q28	Barriers and challenges	1.511	0.806	93.4	3.3	3.3
Q29	Barriers and challenges	1.440	0.708	95.6	2.7	1.6
Q30	Barriers and challenges	1.775	0.945	76.9	19.2	3.8
Q31	Barriers and challenges	1.615	0.804	89.6	7.1	3.3

Strong agreement is seen with most items of awareness, and this is reflected in the item level results. For the green chemistry field, the results of the agreement showed that Q1 and Q4 have very high agreement, and Q6 has the lowest agreement among the awareness items. Students' confidence in different solvents was less for determining relatively safer solvents and more hazardous solvents. This result is significant as a practical aspect of linking green chemistry to laboratory safety.

Awareness of organic solvent hazards was generally good. Students agreed strongly with statements on inhalation toxicity, flammability, skin exposure, and respiratory / nervous system effects. Agreement was less in regard to reading warning labels and reading MSDS before handling chemicals. This indicates that students may be more attuned to the dangers of using solvents generally than to information-gathering safety procedures.

Safe laboratory practices awareness results had the highest level of overall agreement. The students reported a high awareness of gloves, goggles, use of fume hoods, not smelling chemicals directly, closing solvent containers, following supervisor's instructions, and handling flammable solvents carefully. These results suggest that students perceived themselves as very familiar with general laboratory safety guidelines.

Awareness regarding chemical wastes was also good. Students strongly agreed that all organic waste should go in a designated container, mixing chemical wastes randomly could cause dangerous reactions, and that the disposal of organic solvents in the sink could cause environmental damage. The item concerning the reduction of material in experiments had only relatively low agreement, possibly suggesting that students are more aware of the waste disposal than of waste reduction.

The barriers and challenges domain showed that students perceived several obstacles, particularly the absence of designated chemical waste containers, limited knowledge of green chemistry principles, limited practical training, and the need for more training sessions on the safe handling of organic solvents. These findings indicate that students' self-reported awareness does not necessarily mean that laboratory practice is fully safe or green.

4.4 Independent-Samples Comparisons

Because of the unequal sample sizes, Welch's independent-samples t-test was used to compare awareness scores for two-group variables.

Table 6. Independent-Samples Comparisons for Overall Awareness Score

Grouping variable	Group 1	n	Mean	SD	Group 2	n	Mean	SD	t	df	p
Gender	Male	64	1.527	0.797	Female	118	1.476	0.407	0.486	81.18	0.628
Studied organic chemistry course	Yes	139	1.395	0.379	No	43	1.814	0.897	-2.983	46.73	0.005
Studied organic chemistry laboratory	Yes	135	1.384	0.362	No	47	1.809	0.879	-3.215	51.55	0.002
Specialization, collapsed	Chemistry	156	1.436	0.414	Other related specialties	26	1.840	1.080	-1.882	26.24	0.071
Number of chemistry laboratories, collapsed	Three labs or more	128	1.388	0.382	Fewer than three labs	54	1.744	0.826	-3.030	62.77	0.004

There was no significant relationship between overall self-reported awareness and gender. Students who had taken an organic chemistry course reported significantly higher overall awareness than students who had not taken an organic chemistry course. In addition, students with experience in an organic chemistry lab also reported significantly higher levels of overall awareness than students without organic chemistry lab experience. Students who had taken three chemistry laboratories or more showed significantly higher awareness than students in fewer than three labs. When specialties were collapsed into chemistry and other related specialties, specialization was not significantly associated with the overall awareness score.

This study indicates that there might be a stronger relationship between academic and laboratory exposure and students' perceptions of their awareness than between gender and specialization alone. The study was cross-sectional, though, and these findings should be interpreted as associations, not causes.

Effect sizes were small for gender (d = 0.09) and moderate for organic chemistry course completion (d = 0.77), organic chemistry laboratory completion (d = 0.78), specialization comparison (d = 0.73), and completion of three or more chemistry laboratories (d = 0.65). Lower mean scores in the exposed groups reflected stronger self-reported awareness. Although the specialization comparison showed a moderate effect size, the result was not statistically significant and should be interpreted cautiously because of the unequal group sizes.

4.5 One-Way ANOVA by Academic Level

Table 7. One-Way ANOVA by Academic Level

Domain	df between	df within	F	p	Significant at .05
Green chemistry awareness	3	178	0.470	0.703	No
Organic solvent hazard awareness	3	178	2.331	0.076	No
Safe laboratory practices awareness	3	178	1.104	0.349	No
Chemical waste management awareness	3	178	1.178	0.319	No
Barriers and challenges	3	178	1.641	0.182	No
Overall awareness scale, excluding barriers	3	178	1.367	0.254	No

Results from the one-way ANOVA indicated that there were no significant differences among the academic level in awareness scores. These results suggest that there was no significant difference in the awareness domains or in the overall awareness scale between academic levels. In contrast, course and laboratory exposure appeared more closely associated with self-reported awareness than academic level.

The ANOVA effect sizes were small across domains (eta squared, η^2 = 0.008–0.038), indicating that academic level explained only a limited proportion of variance in the awareness and barriers scores.

4.6 Correlations among Questionnaire Domains

All correlations were significant at the level of $p < 0.001$.

Table 8. Pearson Correlation Matrix among Questionnaire Domains

Domain	Green chemistry	Solvent hazards	Safe lab practices	Waste management	Barriers	Overall awareness
Green chemistry	1.000	0.722	0.722	0.702	0.698	0.865
Solvent hazards	0.722	1.000	0.876	0.810	0.685	0.935
Safe lab practices	0.722	0.876	1.000	0.853	0.700	0.946
Waste management	0.702	0.810	0.853	1.000	0.660	0.909
Barriers	0.698	0.685	0.700	0.660	1.000	0.752
Overall awareness	0.865	0.935	0.946	0.909	0.752	1.000

All the awareness domains were positively and highly correlated. Because lower scores reflected stronger agreement, the positive correlations indicate that students with stronger agreement in one domain tended also to show stronger agreement in other domains. Safe laboratory practice awareness and organic solvent hazard awareness were the aspects of greatest correlation with the overall awareness scale, as well as chemical waste management awareness. These results indicate that perceived green chemistry awareness, solvent hazards, laboratory safety, and waste management were interconnected for students.

The barriers and challenges domain was also significantly correlated with the awareness domains. This is not to say that barriers are equated with increased awareness. However, it indicates that the students who agreed more with awareness items also tended to perceive more barriers to applying safe and green lab practices.

4.7 Open-Ended Responses

Table 9. Thematic Summary of Open-Ended Responses

Theme	n	%	Illustrative summary

Theme	n	%	Illustrative summary
Training/workshops on laboratory safety and green chemistry	79	43.4	More practical training, workshops, and awareness sessions on safety and green chemistry.
General/uncategorized suggestions	58	31.9	General calls for improvement in awareness, commitment, and laboratory procedures.
Safer alternatives and reducing hazardous solvent use	25	13.7	Use safer alternatives, reduce hazardous solvents, and select less toxic materials where possible.
Waste containers and waste segregation/disposal	9	4.9	Provide designated waste containers and improve waste segregation and disposal procedures.
Curriculum integration and practical application	5	2.7	Integrate green chemistry and laboratory safety more clearly into curricula and practical sessions.
Supervision, rules, and enforcement	4	2.2	Strengthen supervision, enforce laboratory rules, and follow clear safety instructions.
Availability of safety equipment and laboratory infrastructure	2	1.1	Improve the availability of PPE, ventilation, fume hoods, and other safety infrastructure.

The optional open-ended question (Q32) was not measured on a Likert scale and so was analysed thematically rather than statistically. The quantitative data findings were supported with the qualitative responses. Continuous practical training, workshops, and awareness programmes on laboratory safety and green chemistry were the most common suggestions by the students. The other responses were safer alternatives to hazardous solvents, reducing the amount of chemicals used, conducting experiments on a micro-scale, segregating waste streams, providing designated waste containers, making it easier to follow the safety procedures, supervision and incorporating the curriculum. The students' answers showed that awareness alone was not enough to promote green chemistry and safety in the laboratory, but that practical and institutional support were also required.

4.8 Discussion of Main Findings

Overall, students showed high self-reported awareness of green chemistry principles, organic solvent hazards, safe laboratory practices and chemical waste management was high. The highest level was found for awareness of safe practices in the lab. This may be because certain safety measures such as gloves, goggles, not smelling chemicals directly, closing the containers of solvents and following the instructions of the supervisor are often repeated in the laboratory.

The awareness in green chemistry was somewhat lower than the rest of the awareness domains. The least strong item was students' self-reported ability to differentiate relatively safer solvents from highly hazardous solvents. Safer solvent selection is a practical link between green chemistry and laboratory safety, and solvent-selection guides compare solvents by health, safety, environmental and practical considerations (Byrne et al., 2016). So, Q6 is not a broad awareness question, but rather a curriculum target.

Reading warning labels and reading MSDS/SDS before handling chemicals also showed relatively lower agreement, indicating a need for practical training in hazard communication. SDS/MSDS and hazard labels are central tools because they provide information about chemical properties, hazards, protective measures, and safe handling procedures (Occupational Safety and Health Administration, 2012). Laboratory teaching should therefore move beyond reminding students that chemicals can be dangerous and should train them to use SDS/MSDS and hazard labels before chemical handling.
The results also revealed that students who completed an organic chemistry course, completed an organic chemistry laboratory or three or more chemistry laboratories demonstrated significantly higher self-reported awareness. This indicates that chemistry

content and repeated laboratory activity are associated with higher perceived awareness. The findings must, however, be interpreted as the self-reported findings of a cross-sectional study, and so, do not imply that these courses caused greater awareness.

Findings from the barriers and challenges domain showed that students perceived practical barriers to applying green chemistry and laboratory safety. The main obstacles were the unavailability of chemical waste disposal facilities, limited knowledge of green chemistry principles, limited practical training, and the need for additional workshops. This is consistent with the view that green chemistry and laboratory safety implementation depends not only on student awareness, but also on curriculum design, training, safety culture, waste-management planning, and institutional practices (National Research Council, 2011; Aubrecht et al., 2019; O'Neil et al., 2020).

The free-form answers to Q32 also confirmed this pattern; students consistently associated improved green chemistry and laboratory safety with practical training, safer alternatives, laboratory waste-management infrastructure, curriculum incorporation, and supervision. The qualitative themes therefore strengthened the quantitative finding that awareness alone is insufficient without practical and institutional support.

The results of the study should be interpreted with caution as it relied on self-reported awareness and perceptions. Social desirability bias is a potential limitation of self-report instruments, particularly those that include items that refer to "expected" or "socially approved" behaviors of safety or responsibility (Miller, 2012; Lavidas et al., 2022). The high consensus scores do not therefore represent actual knowledge or laboratory practice.

Overall, the study indicates that students perceived themselves as knowledgeable about a number of safety aspects of the laboratory, as well as green chemistry, particularly basic safe laboratory practices. Meanwhile, the findings suggest further practical training may be needed to better prepare students for the work they are expected to perform, particularly in the areas of safer solvent choice, understanding SDS/MSDS, understanding hazard labels, chemical waste segregation, and waste prevention. These can be reinforced with practical workshops, curriculum integration and more explicit training in safe and sustainable laboratory decision making.

5. Conclusion and Recommendations

5.1 Conclusion

The present study focused on chemistry and chemistry-related students' self-reported knowledge of green chemistry principles, hazards of organic solvents, safety practices in the educational laboratory, chemical waste management, and challenges in the educational laboratory.

Students' overall self-reported awareness was high in the major domains of awareness. The highest self-reported awareness was seen with safe laboratory practice, followed by chemical waste management and organic solvent hazard awareness. In comparison, students' self-reported awareness of green chemistry was relatively lower, but they generally agreed with most of the green chemistry statements.

The item-level results indicated that students' level of confidence in the differentiation of relatively safer solvents and highly hazardous solvents was lower. This finding is significant as it relates directly to green chemistry principles and laboratory safety. Additionally, less agreement was noted regarding reading warning labels or MSDS/SDS before handling chemicals, indicating a need for more hands-on training in hazard communication.

The students who completed an organic chemistry course, an organic chemistry laboratory or three or more chemistry laboratories reported significantly higher levels of self-reported awareness relative to the comparison groups. There was no significant difference in overall awareness score when compared by sex and academic level. A significant relationship between academic and laboratory exposure and perceived awareness was found, but this could not be attributed to any causal relationship as the study is cross-sectional.

Additionally, students noted a number of obstacles to green chemistry and lab safety, particularly the lack of chemical waste containers, lack of knowledge of green chemistry principles, limited training experience, and a need to expand their knowledge of handling organic solvents safely through more workshops. The open-ended answers confirmed the students' grasp that laboratory safety and waste disposal, safer alternatives to solvents, curriculum integration, and supervision are all actions that promote green chemistry and laboratory safety.

Overall, the results indicate that students feel they have knowledge of some topics in laboratory safety and green chemistry, especially basic safe laboratory practices. The results do indicate, though, that there is a need for improved practical training in safer solvent selection, SDS/MSDS use, hazard-label interpretation, waste segregation and waste prevention. The results of the study were obtained from self-reported data, so they should be interpreted as what the students feel they know and perceive about their own practice rather than as actual knowledge and observations made in the laboratory.

5.2 Recommendations

The findings of the study suggest that there is a need for chemistry education to have more workshops on green chemistry principles and safe use of organic solvents.

Laboratory safety training should involve hands-on practice in reading SDS/MSDS, interpreting hazard symbols and pictograms, and selecting appropriate personal protective equipment before using chemicals.

Chemistry lab courses should have more explicit instruction on how to choose safer solvents, particularly contrasting relatively safer solvents to highly hazardous solvents.

Chemical waste management should be improved through clear waste-segregation protocols, designated waste containers, and training on the environmental risks of improper waste disposal.

Green chemistry principles should be made a more explicit part of theoretical and practical chemistry courses, particularly in relation to solvent selection, waste prevention, reduction of hazardous materials, and safer decision-making in chemistry laboratories.

This would help students think about the relationship between safety in the lab and sustainability.

In the future, objective knowledge tests, practical safety assessment or laboratory observations could be used to compare students' self-reported awareness to the actual knowledge and observed practices in the lab.

Future studies may also involve a more diverse and balanced sample of universities and chemistry-related programs to enhance the generalizability of the results.

5.3 Limitations of the Study

The results of this study have some limitations. First, a self-reported questionnaire was used for the study, therefore, the results reflect students' own perceptions of their awareness and not their actual knowledge and/or laboratory practices. Second, the cross-sectional study design precludes causal inferences for the effect of the organic chemistry course or laboratory experience on awareness. Thirdly, the findings may not be generalizable due to the convenience and snowball sampling methods. Fourth, some groups in the demographic and academic subgroups were small or unbalanced and therefore group comparisons had to be interpreted with care. Finally, the questionnaire items were predominantly positively formulated and could thus have led to increased levels of agreement and may have been influenced by social desirability bias (Miller, 2012; Lavidas et al., 2022).

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Ethical Considerations and Informed Consent to Participate: This study was voluntary. All participants gave informed consent to complete the questionnaire via electronic means. All participants were assured that the data that would be collected were for scientific research and that their answers would be treated confidentially. The dataset used for analysis did not contain any names, email addresses or identifying information. Responses were analyzed anonymously and in aggregate form.
Data Availability Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Appendix A. Questionnaire

Questionnaire title: Questionnaire on Chemistry Students' Self-Reported Awareness of Green Chemistry Principles and the Safe Use of Organic Solvents

Questionnaire introduction: Dear student, this questionnaire is designed to explore chemistry students' self-reported knowledge of Green Chemistry principles and about the use of organic solvents safely in educational laboratories. The information gathered will be for scientific research only and all answers will be kept fully confidential. It is not compulsory and there are no correct or incorrect answers. Therefore, please answer honestly and objectively. Many thanks for your cooperation.

Consent to participate: Do you agree to have your participation in this study? Candidates have to choose between the following responses: Yes, I agree; No, I do not agree.

Note. The questionnaire was presented in Arabic via Google Forms and then translated into English for reporting purposes. The items on the Likert scale were coded as: 1 = Strongly Agree; 2 = Agree; 3 = Neutral; 4 = Disagree; and 5 = Strongly Disagree. Agreements are indicated by lower mean scores. Lower mean scores represent increased self-reported levels of awareness for the awareness domains. The barriers and challenges domain was interpreted separately as these items are directly related to increasing barriers and challenges, rather than the level of awareness.

Table A1. Demographic and Academic Information

No.	Question	Response options
D1	Gender	Male; Female
D2	Academic level	Completed second year; Will begin third year; Third year; Other
D3	Specialization	Chemistry; Applied Chemistry; Biochemistry; Pharmacy; Biological Sciences; Other
D4	Have you studied an organic chemistry course?	Yes; No
D5	Have you studied an organic chemistry laboratory course?	Yes; No
D6	Number of chemistry laboratory courses completed during your university study	One laboratory; Two laboratories; Three laboratories or more; No laboratory completed
D7	Have you previously received laboratory safety training?	Yes; No

Table A2. Likert-Scale Questionnaire Items

No.	Domain	Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Q1	Green chemistry principles	I am aware that green chemistry aims to reduce chemical waste produced from experiments.	1	2	3	4	5
Q2	Green chemistry principles	I believe that choosing less toxic solvents is one of the important principles of green chemistry.	1	2	3	4	5
Q3	Green chemistry principles	I am aware that reducing the use of hazardous chemicals is an essential part of green chemistry.	1	2	3	4	5
Q4	Green chemistry principles	I believe that green chemistry helps protect the environment and public health.	1	2	3	4	5
Q5	Green chemistry principles	I am aware that reducing energy consumption in chemical reactions is one of the principles of green chemistry.	1	2	3	4	5
Q6	Green chemistry principles	I can distinguish between relatively safer solvents and highly hazardous solvents.	1	2	3	4	5
Q7	Organic solvent hazards	I am aware that some organic solvents may be toxic when their vapors are inhaled.	1	2	3	4	5
Q8	Organic solvent hazards	I am aware that some organic solvents are highly flammable.	1	2	3	4	5
Q9	Organic solvent hazards	I am aware that skin contact with organic solvents may cause health problems.	1	2	3	4	5
Q10	Organic solvent hazards	I am aware that some organic solvents may negatively affect the respiratory system or nervous system.	1	2	3	4	5

No.	Domain	Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Q11	Organic solvent hazards	I read the warning label on the solvent container before using it.	1	2	3	4	5
Q12	Organic solvent hazards	I am aware of the importance of reading the Material Safety Data Sheet/Safety Data Sheet (MSDS/SDS) before handling chemicals.	1	2	3	4	5
Q13	Safe laboratory practices	I am aware of the importance of using appropriate gloves when handling organic solvents.	1	2	3	4	5
Q14	Safe laboratory practices	I am aware of the importance of wearing safety goggles while working in the laboratory.	1	2	3	4	5
Q15	Safe laboratory practices	I am aware that a fume hood should be used when handling volatile solvents or solvents with strong odors.	1	2	3	4	5
Q16	Safe laboratory practices	I am aware that chemicals should not be smelled directly inside the laboratory.	1	2	3	4	5
Q17	Safe laboratory practices	I am aware that solvent containers should be closed after use.	1	2	3	4	5
Q18	Safe laboratory practices	I am aware of the importance of following the instructions of the supervisor or instructor when handling organic materials.	1	2	3	4	5
Q19	Safe laboratory practices	I am aware of the need to handle flammable solvents carefully near sources of heat or flame.	1	2	3	4	5
Q20	Chemical waste management	I am aware that disposing of organic solvents in the sink may cause environmental harm.	1	2	3	4	5
Q21	Chemical waste management	I am aware that organic waste should be placed in designated waste containers.	1	2	3	4	5
Q22	Chemical waste management	I believe that separating chemical waste according to its type is necessary inside the laboratory.	1	2	3	4	5
Q23	Chemical waste management	I am aware that randomly mixing chemical waste may lead to dangerous reactions.	1	2	3	4	5
Q24	Chemical waste management	I believe that reducing the amount of materials used in experiments helps reduce chemical waste.	1	2	3	4	5
Q25	Barriers and challenges	Lack of practical training reduces students' ability to apply laboratory safety rules.	1	2	3	4	5
Q26	Barriers and challenges	The unavailability of safer alternatives to organic solvents limits the application of green chemistry principles.	1	2	3	4	5

No.	Domain	Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Q27	Barriers and challenges	High student numbers inside the laboratory affect compliance with safety procedures.	1	2	3	4	5
Q28	Barriers and challenges	Limited awareness of green chemistry principles makes their application limited in educational laboratories.	1	2	3	4	5
Q29	Barriers and challenges	The absence of designated containers for chemical waste weakens safe disposal practices.	1	2	3	4	5
Q30	Barriers and challenges	I believe that university curricula do not focus sufficiently on green chemistry applications.	1	2	3	4	5
Q31	Barriers and challenges	I need more training workshops on the safe handling of organic solvents.	1	2	3	4	5

Table A3. Open-Ended Question

No.	Question type	Question
Q32	Open-ended	In your opinion, what is the most important action that could help improve the application of green chemistry principles and laboratory safety in chemistry laboratories?