Establishment of Green Chemistry Awareness Instrument for secondary school students

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Article Info

Article history:

Received Dec 17, 2021
Revised Aug 11, 2022
Accepted Sep 3, 2022

Keywords:

Awareness
Development
Green chemistry
Instrument

ABSTRACT

The purpose of the study was to develop a valid and reliable instrument that can assess green chemistry awareness among secondary schools. This study applied a quantitative approach with a survey design to obtain information related to items and constructs to build an instrument to access student awareness of green chemistry. The study population involved all form four students who are taking a chemistry subject in 85 secondary schools in the State of Melaka, Malaysia. This study involved two phases and all the respondents were selected using a random sampling method. The first phase involved 700 respondents and the second phase involved 500 respondents. The pilot study involved 100 students who were also randomly selected from the same population but not involved in phase I and phase II study. The data obtained were analyzed using Statistical Package for Social Science (SPSS) software. As a result, the Green Chemistry Awareness Instrument (GCAI) was developed. GCAI contains six constructs with a total of 29 items; knowledge (eight items), attitudes (six items), value (eight items), and awareness lighting (seven items). GCAI was found to have good content and construct validity as well as high reliability. Hence, it can assess green chemistry awareness among secondary school students. GCAI also has the advantage of being easily administered.

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1. INTRODUCTION

Sustainable development is the ability of physical development and cultural co-well-being as well as respect for natural resources for the needs of future generations. The principles of sustainable development emphasize knowledge, values and skills in renewing the quality of life without damaging the world now and in the future. Sustainable development is based on the relationship between economic development, environmental quality and social equity. Therefore, every individual needs to be trained to manage natural resources for the needs of future generations. Sustainable development education is a learning process based on the principles of balance between universal well-being at all levels of education [1]. Sustainable development education supports the five foundations in learning to provide quality education and promote a balance of human development. It consists of learning to know, learning to be, learning to live together, learning to do and learning to change yourself and society. Most countries support the inclusion of sustainable development education in the formal education system at the primary and secondary levels. The implementation of this sustainable development education requires a restructuring of the curriculum as well as the teaching and learning process [1]. The underlying elements of sustainable development education also require adaptation in the learning and teaching process across the curriculum.

Sustainable development education can be applied in the curriculum of subjects in schools directly or indirectly especially in chemistry subjects [2]. According to Ithnin, Teratani, and Matsubara [3], chemistry could play role in green and sustainable development. The application can be done through the practice of green chemistry in science subjects in general and chemistry subjects in particular. Green chemistry is an action to the need to reduce the environmental destruction caused by man-made materials as well as their production processes [4]. The concept of green chemistry incorporates new approaches to the synthesis, processing, and application of chemicals to reduce threats to health and the environment. The term green chemistry was first used in a program organized by the United States Environmental Protection Agency [5]. The program aims to implement sustainable development in chemical as well as industrial technology.

Green chemistry is a proactive approach to prevent pollution as early as the design stage of product production. According to Anastas and Eghbali [6], green chemistry is a new field that emphasizes efforts at the molecular level to achieve sustainability. Careful planning is mandatory in the use of non-hazardous chemicals to reduce by-products during the production process of a material.

There are 12 principles underlying the green chemistry concept: i) Prevention is the principle that states it is better to avoid waste than to treat or clean the resulting waste; ii) Atomic economy where synthetic methods should be designed to maximize all the chemicals used in the process into the final product; iii) Chemical synthesis that less hazardous which means that synthetic methods designed to use and generate materials that have low toxicity or are not harmful to human health and the environment; iv) Design safe chemicals where chemical products need to be designed to perform the desired function as well as minimize the toxicity of the material; v) Safer auxiliaries and solvents which means the use of auxiliary materials (solvents, separating agents) shall be safe and non-hazardous if used; vi) Design for energy efficiency which means the energy requirements of the chemical process are necessary recognized for environmental and economic impact as well as need to be reduced. Likely, synthetic methods should be carried out at atmospheric temperature and pressure; vii) Use renewable fuels which means technically and economically the use of renewable raw materials is feasible due to their inexhaustible nature; viii) Reduce derivatives where derivatives are not important should be reduced or avoided if possible, to reduce the addition of reagents as well as the production of residues; ix) Catalysis that means the use of catalytic reagents is best for stoichiometric reagents; x) Design for degradation means chemical products should be designed to be non-degradation products hazardous to the environment; xi) Real-time analysis for pollution prevention where methodological analysis needs to be further developed to enable real-time, in-process monitoring and control; xii) Safe chemicals for accident prevention where materials and forms of materials used in materials process chemistry should be selected to minimize possible interference in the event of an accident involving chemicals, including radiation, explosions, and fire [7].

The concept of sustainable development education and green chemistry practices are great directly in the process of developing capabilities, attitudes and values towards the environment. The existing problems related to the environment need to be solved through education because the elements contained in the curriculum enhance the country towards sustainable development in the future [8], [9]. Therefore, students should empower themselves with sustainability knowledge and understanding of the human world; to learn decision making based on ethical, social, environmental and economic issues; and to learn to act and behave in accordance with sustainable development thinking [10]. This needs a more effective education and capacity building and a much broader understanding and implementation of Green chemistry curricula at various levels, from school to university in all countries [11].

Environmental awareness programs today target the environmental, social and economic aspects of sustainable living, such as the Sustainable Schools Award. However, the current level of students' awareness of the environment is still low and requires continuous solutions [8], [12]. Awareness of green chemistry practices should not only be nurtured but should be practiced by every individual in society. The practice of green chemistry at the school level is very important to improve the quality of life of the community and balance economic development [4]. However, not much information is available as research on green chemistry among school students is still lacking. Currently, the chemistry curriculum implemented in schools has elements related to the aspect of awareness in environmental care but this aspect is rarely emphasized in the learning and teaching process. This is because the process of using chemicals during practical in school laboratory mostly does not involve the principles of green chemistry. The practice of green chemistry can promote critical thinking, problem-solving, and communication skills among students towards sustainable development. Therefore, this practice should be applied among school students while conducting chemistry practical. The application can be done effectively if there is clear and complete information about students' awareness related to green chemistry. Accordingly, the level of green chemistry awareness among students needs to be explored and identified to enable improvements in practice in the best possible way.

There are several instruments available and can be used to determine the level of awareness about the environment, such as the Questionnaire on environmental values [13], the Environmental literacy survey [14], Environmental attitude and Knowledge scale [15], the Environmental attitude and Ecological behavior [16], and the New environmental paradigm (NEP) [17]. However, instruments to measure the level of awareness of green chemistry as a whole including the 12 principles of green chemistry are still lacking. Therefore, there is a need for the development of instrument to determine the knowledge, attitudes, values, and awareness of green chemistry among school students for sustainability in the future. This instrument can be used as a tool by teachers and other parties in determining the level of green chemistry awareness and also it added to existing environmental instruments.

2. RESEARCH METHOD

This study applied a quantitative approach with a survey design to obtain information related to items and constructs to build an instrument to access student awareness of green chemistry. The study population involved all form four students who are taking a chemistry subject in 85 secondary schools in the State of Melaka, Malaysia. This study involved two phases and all the respondents were selected using a random sampling method. The first phase involved 700 respondents and the second phase involved 500 respondents. The pilot study involved 100 students who were also randomly selected from the same population, but not involved in first phase and second phase of the study. The data obtained were analyzed using Statistical Package for Social Science (SPSS) software.

3. DEVELOPMENT OF THE GREEN CHEMISTRY AWARENESS INSTRUMENT

In this study, the development of the Green Chemistry Awareness Instrument (GCAI) used a common three-stage approach [18], [19]. The three stages were: i) Stage one identification of green chemistry awareness scales; ii) Stage two involved writing individual items within the scales; and iii) Stage three involved field-testing items followed by item analysis and validation procedures. These three steps were also used by previous researchers [20], [21].

3.1. First stage: Identification of main green chemistry awareness scales

There were four steps taken to identify and determine the main scale or constructs of the GCAI. The first step taken was to review the relevant literature on environment assessment instruments especially related to green chemistry including books, journals and articles of previous studies conducted either locally or abroad. The second step, researchers viewed and checked previously constructed instruments to identify relevant scales or constructs and items suitable for GCAI. This was important because if there were any suitable constructs or items that could be adapted in the development of an instrument. In the third step, the researcher did a brainstorming and discussion session with the panel of experts and experienced teachers to obtain knowledge, information, opinions and ideas related to green chemistry. This step was crucial because based on the panel’s expertise, the constructs of green chemical awareness instruments can be embodied, strengthen and supported. The final step involved the process of selecting and determining the most appropriate and relevant constructs of the GCAI based on findings of all preceding steps.

3.2. Second stage: Construction of items in each construct

There were three steps involved in this stage. First, researchers adapted some suitable and relevant items from existing environment assessment instruments to be included in the newly developed instrument. The researcher also constructed new items based on literature and discussions on each identified construct. The adapted and constructed items will take into account the 12 principles of green chemistry.

Second step, all the items in the newly developed instrument were sent to experts for validation. In this study, the validation process involved five experts: a professor from University of Kebangsaan Malaysia, three senior lecturers from Sultan Idris Education University and two senior lecturers from Universiti Teknolologi Malaysia. They are experts in their fields, such as education, environment and construction of instruments. The validity performed is face validity and content validity. Face validity was assessed by experts by providing comments and inserting appropriate scores to assess aspects of item clarity, sentence length, negative words, use of terms and technical language. Content validity, on the other hand, involves an expert's expertise to evaluate and determine whether the built instrument is measuring what it is supposed to measure, in this case, the content of the instrument measure students' awareness of green chemistry.

Third, the pilot study conducted was aimed to ensure that each constructed item had appropriate characteristics as an instrument such as validity, reliability, administrability and interpretability before the actual study was conducted [22]. A pilot study was carried out on 100 randomly selected from students in

Melaka to determine the reliability of the constructed instrument. Reliability values were measured using Cronbach Alpha. Values of Cronbach Alpha more than 0.7 indicate that the instrument has good reliability.

3.3. Third stage: Field testing and data analysis

The third stage involved administration of draft instrument (field testing) to a larger sample to collect sufficient data and then performed the statistical analysis. The field testing and data analysis were carried out two times which are phase I and phase II. The two phases of administration were aimed to reduce the items so that the selected items are ultimately accurate, appropriate and have high validity and reliability. Phase I involved 700 respondents while phase II involved 500 respondents. Both phases were used form four chemistry students in the State of Melaka. They were selected because they have been in school for several years and were considered mature and able to provide valid and reliable information on green chemistry awareness.

The exploratory factor analysis and internal consistency reliability analysis were conducted in each phase to determine the construct validity and reliability of the instrument. Factor analysis was conducted to serve two purposes: i) To refine the GCAI scales and; ii) To provide evidence regarding the validity of the refined constructs. After the construct validity was established, data were also analyzed using Cronbach's Alpha coefficient to measure internal consistency reliability in terms of inter-correlations among items in each construct. Those items that were not highly correlated with their respective scales were removed and data were re-analyzed until all items with the lowest item scale correlation were removed and the alpha coefficient was maximized.

4. RESULTS

The development of the GCAI utilized the intuitive-rational strategy in which only items with high internal consistency remain in the final instrument. It also relied upon the internal strategy [23], whereby only those items with high factor loadings on their scales and low loadings on other scales were kept in the final instrument. This section describes the methods by which GCAI was refined and its validity and reliability were determined.

Based on the reviewed literature, existing instrument and discussion with experts, four constructs were identified to represent the green chemistry awareness: Knowledge, attitudes, value and awareness of green chemistry. A total of 70 items were constructed to represent the four constructs of the Green Chemistry Awareness as shown in Table 1. The knowledge construct has a total of 21 items, the attitude construct contains a total of 17 items, the value construct has a total of 16 items, and the awareness construct contains 16 items. These items include newly developed and some were adapted from an existing instrument. The draft instrument had been revised by experts. All comments and criticisms were taken into consideration and improvements were made on the items in the instrument. For face validity, the experts have written appropriate comments and scores to assess aspects of item clarity, sentence length, negative words, use of terminology and technical use of language. Overall, the experts suggested the use of terms and concepts were easily understood by the respondents' level of knowledge. The use of two aspects in one item also needs to be improved and experts suggest only one aspect in one item. The unclear sentence structure also needs to be amended to avoid confusion among the respondents. Based on expert comments and suggestions, modifications and improvements were made to the written items so that they are clear, concise and easy to understand.

Table 1. Construct and items

No	Construct	Items	Example
1	Knowledge	21	It is better to reduce the reaction waste than to clean up the reaction waste. (Item no.10)
2	Attitude	17	The destruction of the environment due to the pollution of harmful chemicals makes me feel sad. (Item no.25)
3	Value	16	When humans use harmful chemicals, it often causes environmental destruction. (Item no.41)
4	Awareness	16	News in the media regarding seas, rivers and lakes polluted by chemicals were not real. (Item no.58)

For content validity, the expert gave a score for each item constructed. The values of I-CVI and S-CVI were calculated for obtaining the validity value of the items. In this study, the researcher also added a modified Kappa coefficient as additional information. Thus, the CVI and the modified kappa coefficient could ensure expert judgment on the content validity of the item. Content validity analysis based on CVI values and modified Kappa is shown in Table 2.

Table 2. Content validations and modified kappa

Item	I-CVI	k*	Action
2, 5, 6, 7, 9, 10, 12, 14, 15, 16, 17, 18, 25,28, 29, 33, 39, 40, 42, 43, 44, 45, 46, 48,49, 50, 51, 53, 55, 56, 57, 58, 59, 61, 62,64, 65, 66, 67, 68, 69, 70	1.00	1.00	Item retained
1, 3, 4, 8, 11, 13, 19, 20, 21, 22, 23, 24, 26, 27, 30, 31, 32, 34, 35, 36, 37, 38, 41, 47, 52, 54, 60, 63	0.8	0.76	The item needs to be modified

Total relevant items by experts=42; S-CVI/ave=0.92; S-CVI/UA=0.60; Average k*=0.91

Based on Table 2, a total of 70 constructed items were examined and reviewed by five experts. All 70 items constructed had an I-CVI value of 0.8 and above. A total of 42 items had an excellent I-CVI value of 1.00 and an excellent modified kappa of 1.00. While 28 items have an I-CVI value of 0.8 and 0.76 for modified kappa value. The value of S-CVI/ave for the whole item was 0.92 which is at a very good level. This shows that the experts agreed that the items as a whole were relevant and good as the minimum required level was 0.90 [24], [25]. The analysis also shows that the average value of the modified kappa is 0.91 which is also at a very good level. The modified kappa values and S-CVI/ave obtained prove that the items have excellent content validity.

Even though the content validity was good; some modifications were made on items based on comments and suggestions by experts. Table 3 shows an example of some items modified according to expert review comments and recommendations. Item 13 has an I-CVI value of 0.8 and a k* of 0.76. This item is modified because the original item has two different aspects in the item, which are "human health" and "environment". Only one aspect is selected in the item. Examples of other items that have undergone modification are according to the comments and recommendations of experts are those that have an I-CVI value of 0.8 and k* of 0.76. As a result, all 70 items were retained and the expert agreement value was more than 0.80 indicating that the items were good and relevant in measuring the constructs.

Table 3. Example of modified items

Item	I-CVI	k*
Item 13 Chemical synthesis processes that are less toxic to human health and the environment need to be carefully planned. *Item 13: modified* *Less toxic chemical synthesis processes need to be planned so as not to adversely affect the environment*	0.8	0.76
Item 22 I need time with nature to feel happy. *Item 22: modified* *I need time with nature to feel happy*	0.8	0.76
Item 34 One of the most important reasons for green chemistry is to ensure a consistently high standard of living. *Item 34: modified* *One of the most important reasons for green chemistry is to ensure an ongoing good life.*	0.8	0.76

After validation from experts, the draft instrument was administered to 100 form four chemistry secondary schools to determine the reliability. Analysis of the findings showed that the reliability value of Cronbach’s Alpha for the GCAI was 0.906. This value indicated that the GCAI was highly reliable and have good internal consistency.

Field testing and data analysis were conducted in two phases. Phase I involved 700 hundred respondents while phase II involved 500 respondents. After each field testing, exploratory factor analysis was conducted to identify, reduce and organize items into specific constructs and then perform reliability analysis to determine the reliability for each construct in the developed instrument.

Exploratory factor analysis was conducted to determine the construct validity for 70 items employing the principal component analysis and varimax rotation. The Kaiser-Meyer-Olkin Test (KMO) value of the study data was 0.833 and the results of Bartlett’s Test: Bartlett’s Test of Sphericity=11461.323, df=2145, (p<.000). According to previous studies [26], [27], values of KMO between 0.8 and 0.9 are very good and suitable for factor analysis and significant results of Bartlett’s test of sphericity show that the correlation between items is sufficient for factor analysis to be carried out. These tests showed that the sample size was sufficient and factor analysis can be performed on this data to determine the factors and items contained therein. There are a few tools available for researchers to determine the appropriate number of factors to retain. One is the kaiser criterion, which recommends that researchers select factors with Eigenvalues greater than 1.0. The second is the scree test. This examines the scree plot, which is a plot of the eigenvalues along an x-y axis. The point at which the curve decreases and straightens out (i.e., the “elbow” of the graph) is the point where researchers should include all factors before and at the elbow.

From the analysis, 39 items in four factors were found to have eigenvalues greater than 1. The scree plot in Figure 1 also shows four points before straightening out. Thus, the scale was acceptable to have a maximum of four factors. These four factors account for 25.566% of the total variance, while 74.434% of the variance remains unaccounted for.

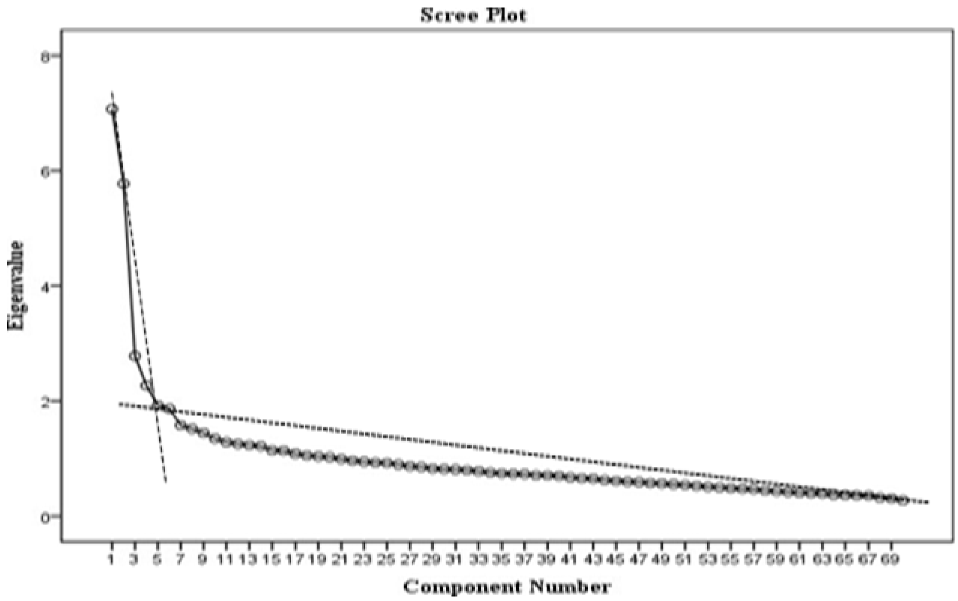

Figure 1. Selection of factors using the scree (phase I)

Table 4 shows eigenvalues and a percentage of variance accounted for by each factor in the GCAI. There were four constructs originally developed for the GCAI field test and after factor analysis, the four constructs remained were the same: Knowledge, attitudes, value and awareness. These 39 items cluster in four factors with Eigenvalues greater than 1. The first factor explains 10.099% of the total variance, while the second factor explains 8.248% of the total variance. In addition, the third factor explains 2.782% of the variance and the last factor explains 2.271% of the total variance. Overall, the four factors explain 25.566% of the total variance. The amount of change in this variance indicates a lower value than the accepted value. The percentage of overall variance accepted was above 50% for social science studies [27]. Table 5 shows the values of the loading factor for the items that have been grouped on a particular factor.

Table 4. Eigenvalues and percentage of variance accounted for by each factor in GCAI

Component	Extraction sums of squared loadings		
	Total	Variance (%)	Cumulative (%)
1	7.069	10.099	10.099
2	5.774	8.248	18.347
3	2.782	3.977	22.322
4	2.271	3.244	25.566

According to Table 5, it was found that a total of 39 items were retained because they had a loading factor value exceeding 0.4. Ten items were grouped in the first component (loading factor 0.433 to 0.706). The second component (loading factor 0.403 to 0.574) contained 11 items. The third component (loading factor 0.458 to 0.665) had 9 items. While there were nine items in the fourth component (loading factor 0.409 to 0.545).

A total of 31 items were removed because they had a low loading factor value which less than 0.4. The excluded items were 62, 33, 35, 17, 7, 46, 39, 56, 21, 52, 15, 14, 58, 34, 54, 42, 12, 16, 48, 57, 40, 29, 61, 51, 13, 8, 60, 59, 18, 10, and 45. The final results of the factor analysis for this phase I show that four main constructs are resulting from 39 items loaded into it as shown in Table 6. The four constructs were known as knowledge of green chemistry (nine items), attitudes toward green chemistry (nine items), values toward green chemistry (11 items), and awareness of green chemistry (10 items).

Table 5. Loading factor of GCAI

Item	Component			
	1	2	3	4
b67	.706			
b64	.690			
b68	.662			
b66	.607			
b53	.568			
b65	.535			
b69	.529			
b63	.516			
b28	.446			
b70	.433			
b44		.574		
b36		.570		
b38		.533		
b37		.509		
b50		.497		
b41		.466		
b20		.462		
b43		.459		
b49		.455		
b19		.432		
b47		.403		
b23			.665	
b24			.620	
b22			.596	
b30			.591	
b31			.547	
b32			.542	
b25			.501	
b26			.493	
b27			.458	
b5				.545
b55				.542
b9				.518
b6				.515
b11				.493
b4				.468
b1				.462
b3				.438
b2				.409

Table 6. Construct and item phase I

Construct	Item number	Number of items
Knowledge	1, 2, 3, 4, 5, 6, 9, 11, 55	9
Attitudes	22, 23, 24, 25, 26, 27, 30, 31, 32	9
Value	19, 20, 36, 37, 38, 41, 43, 44, 47, 49, 50	11
Awareness	28, 53, 63, 64, 65, 66, 67, 68, 69, 70	10

To enhance the development of GCAI, each scale was evaluated again for internal consistency using Cronbach's Alpha coefficients. Table 7 presents the reliability of each scale in GCAI after factor analysis was performed in phase I. The internal consistency reliability (alpha coefficient) ranges between 0.715 and 0.826 for all scales in GCAI specifically; Cronbach's Alpha is 0.715 for knowledge, 0.798 for attitudes 0.739 for S value, and 0.826 for awareness.

Table 7. Cronbach Alpha value for each construct phase I

Construct	Items	Cronbach Alpha
Knowledge	9	.715
Attitudes	9	.798
Value	11	.739
Awareness	10	.826
Total item	39	.818

The alpha value for all constructs was above 0.7 indicating the item had good internal consistency. According to Kline [28], if the alpha value exceeds 0.7 indicates the item or instrument has a satisfactory reliability value. The alpha value for all items in the instrument is 0.818 indicating that the instrument as a whole has excellent internal consistency. Therefore, the value of the reliability of each scale in GCAI is considered acceptable [29]. Although the results of the analysis show that there are 4 constructs with a loading factor above 0.4 and Cronbach's alpha value is good but the cumulative variance was 25.556% which is less than 50% as required for social science studies [27], thus, this instrument needs to be improved. The phase I instrument with 39 items.

Phase II used 39 items from phase I and was administered to 500 respondents. Phase II factor analysis is done to ensure that the items have a high value of loading factor, in addition to reducing and compiling the items of the questionnaire. Factor analysis was conducted on 39 items using the principal component procedures and varimax rotation. The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity were also performed before factor extraction. The KMO Test value of the study data was 0.888 and the results of Bartlett's Test: Bartlett's Test of Sphericity=7472.934, df=741, ($p<.000$). According to previous studies [26], [27], values of KMO between 0.8 and 0.9 are very good and significant results of Bartlett's Test of Sphericity showed that the correlation between the items was sufficient. These tests showed that the sample size was sufficient and factor analysis can be performed on this data in determining the factors and items contained therein for the second time. From the analysis, 29 items in four factors were found to have eigenvalues greater than 1. The scree plot in Figure 2 also shows 4 points before straightening out. Thus, the scale was acceptable to have a maximum of four factors. These four factors account for 52.771% of total variance, while 47.229% of the variance remains unaccounted for. In social science, a difference between 40% and 60% is acceptable and adequate [30]. Table 8 shows eigenvalues and a percentage of variance accounted for by each factor in the GCAI in phase II. There were four constructs originally developed for the GCAI field test in phase I and after factor analysis in phase II, the four constructs remained the same: knowledge, attitudes, value, and awareness.

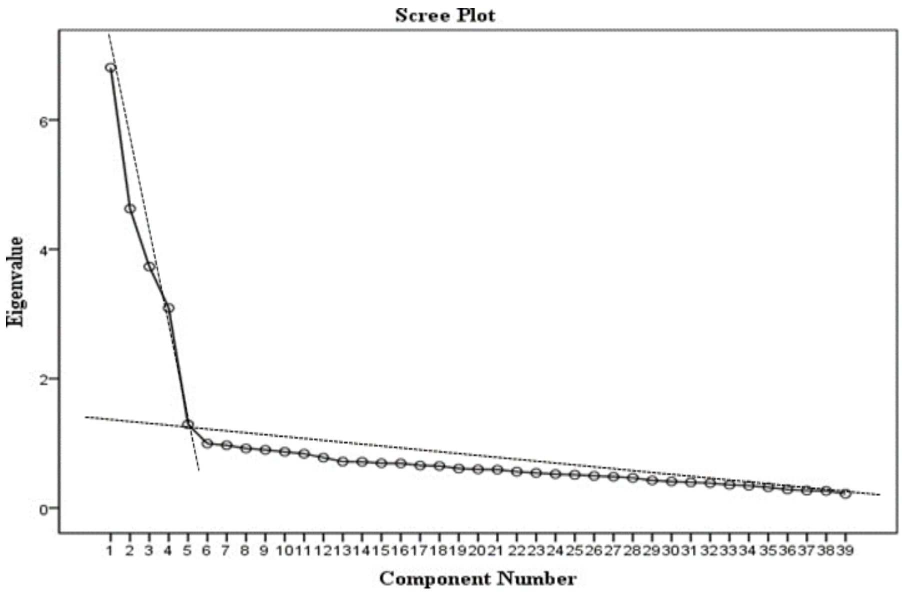

Figure 2. Scree plot phase II

Table 8. Eigenvalues and percentage of variance accounted for by each factor in GCAI

Component	Extraction sums of squared loadings		
	Total	Variance (%)	Cumulative (%)
1	5.378	18.544	18.544
2	3.890	13.413	31.957
3	3.401	11.727	43.684
4	2.635	9.087	52.771

There were 29 items cluster in four factors with Eigenvalues greater than 1. The first factor explains 10.544% of the total variance, while the second factor explains 13.413% of the total variance. In addition, the third factor explains 11.727% of the variance and the last factor explains 9.087% of the total variance. Overall, the four factors explain 52.771% of the total variance. The total variance was acceptable as according to Hair *et al.* [27], the overall percentage variance should be above 50% for social science studies.

Table 9 shows the values of loading factors for the items that have been grouped on a particular factor. Based on Table 10, it was found that a total of 29 items were retained because they had a loading factor value exceeding 0.4. A total of eight items were grouped in the first component (loading factor 0.632 to 0.841). The second component (loading factor 0.618 to 0.812) contained eight items. The third component (loading factor 0.625 to 0.821) had seven items. While there were seven items in the fourth component with a loading factor 0.658 to 0.796). A total of 10 items were removed because they had a low loading factor with a value of less than 0.4. The eliminated items were 3, 15, 17, 18, 21, 24, 29, 31, 34, and 35.

Table 9. Loading factor of refined items of the GCAI phase II

Item	Value	Factor		Attitudes
		Knowledge	Awareness	
b27	.841			
b20	.828			
b25	.763			
b19	.733			
b26	.642			
b22	.639			
b23	.633			
b28	.623			
b7		.812		
b8		.793		
b6		.724		
b4		.721		
b9		.718		
b2		.718		
b5		.641		
b1		.618		
b38			.821	
b39			.730	
b37			.722	
b33			.673	
b36			.671	
b30			.654	
b32			.625	
b10				.796
b14				.743
b13				.708
b11				.704
b12				.699
b16				.658

As a result of phase II exploratory factor analysis, there were 29 items retained as shown in Table 10. The constructs were remaining as knowledge of green chemistry (eight items), attitudes toward green chemistry (six items), values toward green chemistry (eight items) and awareness of green chemistry (seven items). To enhance the development of GCAI, each scale was evaluated again for internal consistency using Cronbach's Alpha coefficients. Table 11 presents the reliability of each scale in GCAI after factor analysis was performed in phase II.

Table 10. Final version phase II construct and items

Construct	Items	
Knowledge	1,2,4,5,7,6,8,9	8
Attitudes	10,11,12,13,14,16	6
Value	19,20, 22, 23, 25, 26, 27,28	8
Awareness	30,32,33,26,37,38,39	7

Table 11. Cronbach Alpha value for each construct phase II

Construct	Total items	Cronbach Alpha value
Knowledge	8	.869
Attitudes	6	.819
Value	8	.868
Awareness	7	.826
Total	29	.835

The internal consistency reliability (alpha coefficient) ranges between 0.819 and 0.869 for all scales in GCAI Specifically, Cronbach's Alpha is 0.869 for knowledge, 0.819 for attitudes, 0.868 for value and 0.826 for awareness. Alpha values for all constructs above 0.7 indicate the item has high internal consistency and of each scale in GCAI is considered acceptable [29]. According to previous research [30], if the alpha value exceeds 0.7, it is indicating the item or instrument has a high reliability value. The alpha value of the instrument is 0.835 indicating that the instrument has a very high internal consistency.

5. DISCUSSION

The purpose of the study was to develop a valid and reliable instrument that can assess green chemistry awareness among secondary school. As a result, the GCAI was developed. GCAI contains six constructs with a total of 29 items contained knowledge (eight items), attitudes (six items), value (eight items) and awareness lighting (seven items). GCAI was found to have good content and construct validity as well as high reliability. Hence, it can assess green chemistry awareness among secondary school students. GCAI also has the advantage of being easily administered.

The numbers of items were appropriate for respondents to answer. It is user-friendly; the grammar and words used in GCAI are simple and easy to understand. It is also very economical to use in terms of time and cost-efficiency. According to Cronbach [31], due to face time constraints among students and teachers, it is important to make sure that the developed questionnaire does not take too much time to be complete. In addition, although the GCAI instrument is constructed to determine the green chemistry awareness among secondary schools, it also can be employed and adapted to a variety of respondents such as university students, college students and the community depending on the creativity of the researchers. This is because the developed construct and items were general and did not specifically for secondary students only. However, attention should be paid to the construction and validity, since it was originally designed for green chemistry awareness among secondary students. Therefore, any improvement must take into account this element, to make this usage meaningful.

6. CONCLUSION

The paper reports the development and validation of an instrument that is designed to assess green chemistry awareness among secondary school students. The development of the Green Chemistry Awareness Instrument is an addition to an existing instrument related to the environment. The findings confirmed the validity and reliability of the GCAI and proved that it is a useful instrument to assess student awareness of green chemistry. However, extensive research is needed to further refine the instrument by including different characteristics of the respondents to create a more valid and reliable measurement of green chemistry awareness.

ACKNOWLEDGEMENTS

This research has been carried out under the Fundamental Research Grants Scheme (FRGS/1/2018/SSI09/UPSI/02/4) provided by the Ministry of Education of Malaysia. The authors would like to extend their gratitude to the Universiti Pendidikan Sultan Idris (UPSI) that manage the grants.

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