Acta Scientiarum

http://periodicos.uem.br/ojs
ISSN on-line: 1807-8664
https://doi.org/10.4025/actascitechnol.v48i1.74016

STATISTICS

Attitudes of health and safety engineering students toward the use of hydrogen as a renewable energy source in Algeria

Chafaa Khatima[1*], Aissani Nassima[1], Guetarni Hadj Islam Mohamed[1] and Juan Luis García Guirao[2]

[1]Laboratory of Industrial Safety Engineering and Sustainable Development, Institute of Maintenance and Industrial Safety, University of Oran 2 Mohamed Ben Ahmed, B.P. 1015 El M'Naouer, 31000, Oran, Algeria. [2]Department of Applied Mathematics and Statistics, Polytechnic University of Cartagena, Murcia, Spain.*Author for correspondence. E-mail: chafaa.khatima@univ-oran2.dz

ABSTRACT. This study explored the attitudes of health and safety engineering students towards hydrogen as a renewable energy source in Algeria. The results indicated a generally moderate attitude with strong support for replacing fossil fuels with new energy technologies. Significant differences were observed between students from the University of Batna and the University of Oran, with Batna students showing more favorable views. No significant differences were found based on gender or academic level. These findings offer valuable insights into future professional perceptions and highlight the importance of tailored educational programs to promote hydrogen energy acceptance. Recommendations for curriculum development and further research to support the advancement of renewable energy in Algeria are discussed.

Keywords: Hydrogen; attitudes; engineer student; health and safety; statistical package for the social sciences.

Received on October 02, 2024.
Accepted on July 23, 2025.

Introduction

In the 21st century, as human needs and demands continue to rise (Barrett et al., 2008), fossil fuels, with their finite reserves (Shafiee & Topal, 2009), have become increasingly questionable as sustainable solutions. It's not merely a matter of their limited supply; the primary concern now centers on their detrimental environmental impact (Bach, 1981) (Trout et al., 2022), the pursuit of carbon-free energy sources and their efficient utilization represents a significant step towards environmental protection (Abbasi et al., 2022), asides from the protection of human health, emissions from fossil fuels have been proven to cause many diseases, especially among children (F. P. Perera, 2017) (Perera & Nadeau, 2022), the fossil fuel-based power generation not only generates carbon dioxide (CO2) as a pollutant but also produces nitrogen oxides (NOx), including NO, NO2 and N2 O, due to the combustion process in air, which contains 78% nitrogen by volume. Additionally, any sulfur present in the fuel leads to the emission of sulfur oxides (SOx). The combined emissions of NOx and SOx play a role in the formation of acid rain, contributing to environmental concerns (Freris & Infield, 2020).

The fundamental concept is to find alternative methods of electricity generation that do not directly emit carbon dioxide, renewable energy sources such as biomass, wind, hydropower, solar energy, and hydrogen (Nnabuife et al., 2023) are considered promising options and over the years, in fact there has been a consistent increase in the proportion of renewable energy in electricity generation, an analysis of global energy data reveals a substantial growth in both the installed capacity and consumption of renewable energy between 2012 and 2021 (Yolcan, 2023), although most of renewable energies depends on the climate such as wind, solar and it can't be produced at best performances in bad weathers, unlike hydrogen energy (Ogden, 1999) (Zhang et al., 2016), hydrogen can be derived from fundamental sources such as water, biomass, natural gas, and coal, among various other origins, and despite being the Earth's most abundant element, hydrogen typically doesn't exist freely and must be extracted from its compounds, including water electrolysis or high-temperature water splitting (McCay & Shafiee, 2020), the inherent characteristics of hydrogen render it a sustainable option for fulfilling global objectives related to reducing greenhouse gas emissions over the long term. It serves as a non-toxic alternative energy carrier, boasting significant potential for energy storage, has a high energy density, produces no greenhouse gas emissions (Abohamzeh et al., 2021), can be employed for storing or generating electricity in power applications (Khan & Iqbal, 2005) and is the future fuel of transport (Singh et al., 2015), (Farrell et al., 2003). Numerous studies have explored the potential of hydrogen as a forthcoming solution to tackle the environmental and energy security challenges presented by current transportation fuels, a topic that requires a clear definition in the upcoming years (Apak et al., 2017), (Li et al., 2023), (Reddy et al., 2020) .

Algeria has great potential for use in renewable energies (Bouraiou et al., 2020), but its integration is very low right now (Abada & Bouharkat, 2018), in addition Studies have indicated that the transition to a hydrogen-based economy in Algeria holds great promise (Boudries & Dizene, 2008), and its potential is quite significant, particularly in the dry and arid southeastern region of Algeria (Mraoui & Menia, 2019), (Blal et al., 2018), (Rahmouni et al., 2015). Several studies have highlighted the significant role of educational background in shaping individuals' attitudes toward emerging energy technologies, including hydrogen, by influencing awareness and perceived risks and benefit (Achterberg et al., 2010). In the context of Algeria and the broader North African region, research on renewable energy acceptance remains limited (Bouznit et al., 2020; Harrouz et al., 2020; Joshi, 2024) Despite Algeria's ambitious plans for renewable energy development, particularly solar and wind, there is a notable gap in understanding public perceptions of hydrogen energy specifically. Based on previous studies (Häußermann et al., 2023), (Djurisic et al., 2020) we conducted a study on engineering students in the category related to the industrial field where renewable energy and hydrogen are relevant, and with the huge transition to renewable energies, the attitudes of future engineers are crucial, and they will play a significant role in this transition; their attitudes can impact the adoption of hydrogen technologies in various industries. Furthermore, to understand the effectiveness of the current educational programs and based on the results, the necessary modifications in the curriculum will be identified for an improved system; in addition, health and safety engineering students need such a domain so that prioritizing safety concerns is important and their willingness to work on solutions that reduce carbon emissions. The aim of this study is to identify health and safety engineering students' attitudes toward the use of hydrogen as a renewable source, future professionals and leaders in their respective fields, and identify the factors that influence their attitudes like gender, level, and the university they belong to identify the potential barriers and emerging educational institutions.

Materials and methods

Participants

A sample of 206 students was randomly selected from the Health and Safety Engineering Institute at two prominent Algerian universities: The University of Oran Mohamed Ben Ahmed and the University of Mostefa Ben Boulaid in Batna. This diverse sample included students from all academic levels, from first-year undergraduates to second-year master's students. The study was conducted during the second semester of the 2022/2023 academic year.

To explore the attitudes of Health and Safety Engineering students towards the use of hydrogen energy in Algeria, a survey questionnaire was developed by the authors of this paper and the individuals mean age in the sample was 23 ± years, Table 1 below provides a detailed breakdown of the sample's characteristics.

Table 1. Sample characteristics.

		Frequency	Percent
Gender	Male	120	58,3
	Female	86	41,7
University	Mohamed Ben Ahmed Oran	83	40,3
	Mostefa Ben Boulaid Batna	123	59,7
Level	First-year Undergraduate	35	17,0
	Second-year Undergraduate	24	11,7
	Third-year Undergraduate	22	10,7
	First year Master	23	11,2
	Second year Master	102	49.5

Instruments

Building upon the theoretical framework and previous studies on data collection tools, such as the work of Zoltán Szakály (Szakály et al., 2020) and the study of Steve Oshiokhai Eshiemogie on Nigerian engineering students (Eshiemogie et al., 2022), the study in Turkey University (Karatepe et al., 2012), (Djurisic et al., 2020), (Häußermann et al., 2023), (Zakaria et al., 2019), (Assali et al., 2019) we constructed a questionnaire to assess the attitudes of health and safety engineer students towards the use of hydrogen energy as renewable energy. The questionnaire consisted of (22 items) within two dimensions in addition to general questions regarding gender, age, university enrollment, and academic level.

• The first dimension, 'The Use of Renewable Energy' included seven items focusing on renewable energy and students' acceptance of replacing fossil fuels.

• The second dimension, 'The Use of Hydrogen Energy' consisted of 15 items assessing their awareness and knowledge of hydrogen energy, as well as their willingness to participate and work on future projects. The questionnaire was reviewed by experts before it was distributed to the students.

We employed a 3-point Likert scale as follows: 'Yes' with three points, 'I'm not sure' with two points, and 'No' with one point. Consequently, the highest possible total score for a respondent was 66 and the lowest was 22.

Psychometric properties

Validity

To ensure the validity of the questionnaire, we calculated the Correlation Coefficient (*Correlation Coefficient*, 2008) between the dimensions and total score of the questionnaire, as shown in Table 2.

Table 2. Correlation between dimensions and total scores.

Correlations				
		total	Renewable Energy	Hydrogen Energy
Total	Pearson Correlation	1	,694**	,970**
Renewable Energy	Pearson Correlation	,694**	1	,505*
Hydrogen Energy	Pearson Correlation	,970**	,505*	1
	**. Correlation is significant at the 0.01 level (2-tailed).			
	*. Correlation is significant at the 0.05 level (2-tailed).			

Table 2 presents the Pearson correlation coefficients between the total score and two dimensions of the questionnaire: Renewable Energy and Hydrogen Energy. The total score was strongly positively correlated with the Hydrogen Energy dimension (r =.970, p <.01), and moderately positively correlated with the Renewable Energy dimension (r =.694*, p* <.01). Additionally, there was a significant positive correlation between the Renewable Energy and Hydrogen Energy dimensions (r =.505, p <.05). These significant correlations indicate that as the scores on the Renewable Energy and Hydrogen Energy dimensions' increase, so does the total score, suggesting that the questionnaire has good internal consistency and construct validity.

Reliability

Reliability (Meeker et al., 2022) was verified using two methods, Cronbach's alpha (Wright, 2013) and the split-half method (Kempf Leonard, 2005), as shown in Table 3.

Table 3. Reliability using Cronbach's alpha and the split-half method.

Item	Cronbach's Alpha if Item Deleted
1- Is it time to replace fossil energy?	,759
2-Do you see relying on renewable energy can impact energy conservation?	,787
3- In 2023, is replacing fossil fuel a must or a choice?	,738
4- Do you update your news on renewable energy progress?	,764
5- Is it possible for Algeria to completely replace fossil fuels with renewable energy sources?	,747
6-Does your university prepares renewable energy activities?	,729
7-If your grades were enough, would you choose to study in Higher National School of Renewable Energy, Environment and Sustainable Development of Batna that became available since 2022?	,779
8-Do you think using the most abundant element (hydrogen) in the universe for our sake is a good idea?	,741
9-Do you know why hydrogen is called 'green hydrogen'?	,739
10-Did you know that green hydrogen can be used as a renewable energy?	,742
11-Have you heard before about the hydrogen rainbow?	,749
12-Do you think producing electricity through hydrogen production is efficient?	,746

13-In your point of view, is it safe using hydrogen as an energy ?	,754
14-As a future engineer, do you think you are aware of the basic safety measures in industrial sector in general, and hydrogen production specifically?	,732
15-Have you conduct any search on hydrogen fuel before?	,728
16-Are you aware of the steps involved in producing hydrogen?	,751
17- Would you be interested to get extra lessons on hydrogen?	,760
18-Do you think the given information on hydrogen energy by your institute is sufficient?	,748
19-In your opinion, would it be better if your institute made courses of such an energy in your curriculum?	,727
20-Would you like to work as a future engineer in hydrogen production industry?	,747
21-Have you done electrolysis of water experiment in your lab before?	,771
22-Do you know that experiment is the same principle to produce hydrogen?	,747
Total questionnaire	,759
Spearman-Brown Coefficient (split half correlation)	,774

From Table 3 we find that Cronbach's alpha coefficient and the split-half correlation coefficient were significant. This is evidence for the reliability of the questionnaire.

Statistical analysis

For data processing, we used SPSS version 28 software (www.ibm.com) and conducted various analyses, including calculating the Pearson correlation coefficient (Hollander et al., 2015), Cronbach's alpha, and independent t-tests (Boslaugh, 2013) for two separate samples and ANOVA (Vik, 2013). The process was performed according to the following stages:

1. In the initial stage, to ensure the reliability of the tool, we computed the Pearson correlation coefficient between the dimensions and overall questionnaire results.
2. In the second stage, to verify the stability of the questionnaire, we calculated Cronbach's alpha and correlation coefficients using the split-half method, in which the survey was divided into two parts.
3. The third phase, which addressed the study's questions, involved performing independent t-tests for two separate samples based on gender and university affiliation. Additionally, an ANOVA was conducted to uncover differences among groups according to academic level, and the results are presented below.

Results

To assess the inclination of the sample students towards the use of hydrogen as a renewable energy source, we calculated the mean, standard deviation, and relative importance index (RII) for each item. Additionally, we determined their rankings to identify the order of importance, as shown in Table 4 and the bar chart in Figure 1.

Table 4. Mean, S.D and RII of The questionnaire.

		Mean	S.D	RII	Ranking BY dimension	Ranking overall	Level
01	Item 1	0,63268	2,0971	69,89634	1	4	H
02	Item 2	0,57769	1,9466	64,88018	4	10	M
03	Item 3	0,7554	1,9951	66,49668	2	7	M
04	Item 4	0,60748	1,8932	63,10036	6	12	M
05	Item 5	0,66252	1,9903	66,3367	3	8	M
06	Item 6	0,81927	1,9175	63,91028	5	11	M
07	Item 7	0,76943	1,7427	58,08419	7	14	M
The dimension of the use of renewable energy					54,68691		M
08	Item 8	2,2087	0,58445	73,61597	3	3	H
09	Item 9	1,6311	0,58419	54,36456	9	16	M
10	Item10	1,432	0,58663	47,72856	11	18	M
11	Item11	1,199	0,51721	39,96267	15	22	M
12	Item12	2,432	0,67913	81,05856	1	1	H
13	Item13	2,3155	0,80997	77,17562	2	2	H
14	Item14	1,8204	0,82744	60,67393	7	13	H
15	Item15	1,2816	0,52111	42,71573	14	21	M
16	Item16	1,3835	0,60366	46,11206	13	20	M
17	Item17	2,0097	0,52257	66,9833	5	6	H
18	Item18	1,5437	0,86984	51,45152	10	17	M

19	Item19	2,0631	0,54181	68,76312	4	5	H
20	Item20	1,9757	0,66582	65,85008	6	9	M
21	Item21	1,6748	0,6137	55,82108	8	15	M
22	Item22	1,4175	0,59304	47,24528	12	19	M
The dimension of the use of hydrogen energy					58,6348		
Total					60,55576		M

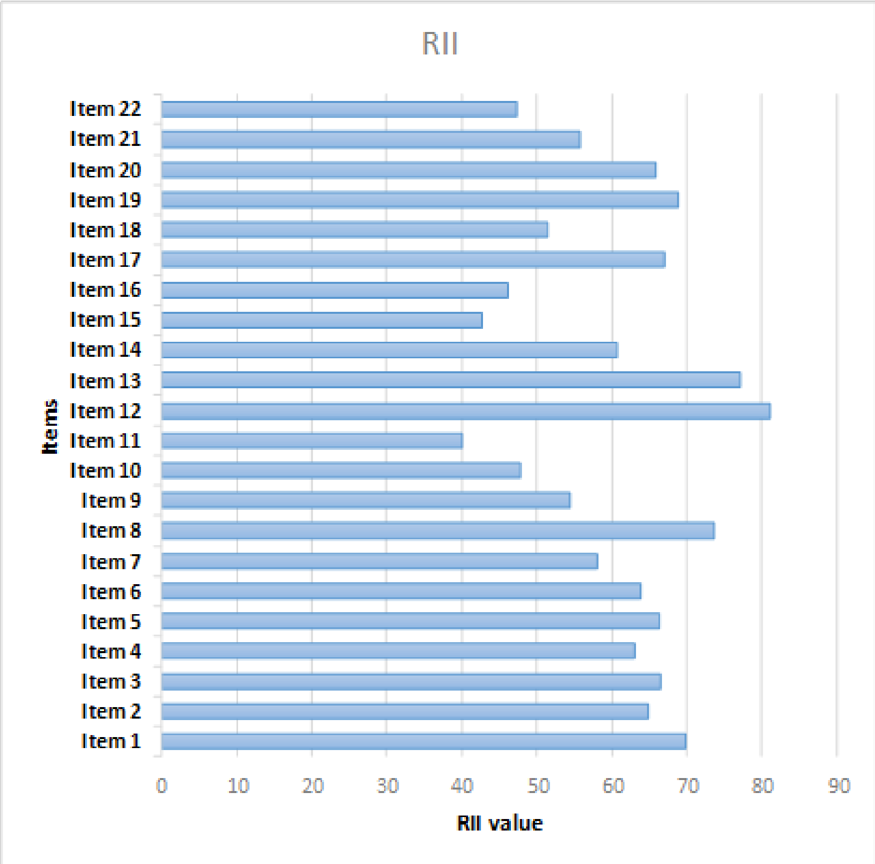

Figure 1. Bar chart showing the Relative Importance Index (RII) values for each item.

The analysis of the questionnaire using the Relative Importance Index (RII) revealed insightful trends in student attitudes towards renewable energy sources. RII is an index that evaluates the relevance of survey elements according to participant responses, varying between 0 and 1, with higher numbers reflecting greater agreement or significance (Boakye & Adanu, 2022) .

In the first dimension, which assessed attitudes towards replacing fossil fuels, the RII values ranged from 58.08419 to 66.49668, indicating a medium level of agreement among students, except for the first item, which had a high RII of 69.89634. This suggests a strong consensus on the urgency of transitioning away from fossil fuel use. The second dimension focuses on the use of hydrogen as a renewable energy source. Here, items 9, 10, 11, 15, 16, 18, 20, 21, and 22 exhibited medium RII values between 39.96267 and 65.85008, while items 8, 12, 13, 14, 17, and 19 showed high RII values ranging from 60.67393 to 81.05856, indicating a significant interest in these areas. The total RII for the first dimension was 54.68691, and for the second dimension, it was 58.6348, both of which were categorized as medium. The overall RII for the questionnaire was 60.55576, suggesting a moderate level of acceptance among the students regarding the use of hydrogen as a renewable energy source. These findings could have implications for educational policy, indicating the potential demand for a more in-depth curriculum on renewable energy technologies, particularly hydrogen. The high RII values for certain items may also guide institutions in developing targeted programs that align with students' interests and the industry's future needs.

To determine whether there are differences in the attitudes of health and safety students towards the use of hydrogen energy based on their university, a t-test was used on two independent samples, as illustrated in Table 5 and the histogram shown in Figure 2.

Table 5. Differences in student attitudes between universities (Batna and Oran).

	University	N	Mean	Std. Deviation	Df	T	Sig
Renewable energy	Oran	83	13,3253	2,06072	204	-1,490	0.69
	Batna	123	13,7561	2,01771			
Hydrogen energy	Oran	83	25,4699	3,89289	204	-3,094	,001
	Batna	123	27,0081	3,20986			
Total	Oran	83	38,8313	5,09380	204	-2,956	,002

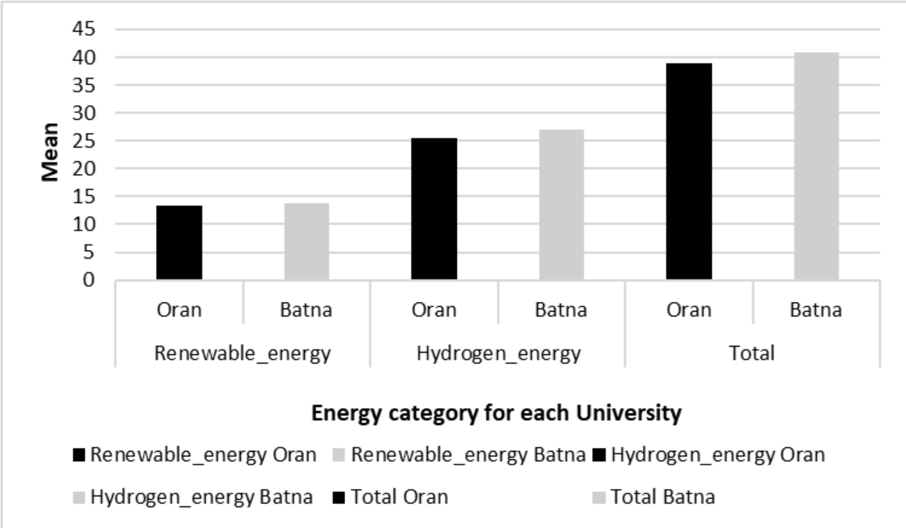

Figure 2. Histogram showing the means for group (Oran and Batna).

From the analysis presented in Table 5, we observe the following.

• First Dimension (Renewable Energy)

The T-test result for the renewable energy dimension between Oran and Batna university students is T =−1.490, with a significance level of P = 0.69. This indicates that there were no statistically significant differences in attitudes towards the use of renewable energy between students from the two universities. Specifically, Oran University students had a mean attitude score of 13.3253 (Std. Deviation = 2.06072), whereas students from Batna University had a slightly higher mean score of 13.7561 (Std. Deviation = 2.01771). Despite the difference in mean scores, a high P-value suggests that this difference was not statistically significant.

• Second Dimension (Hydrogen Energy)

In contrast, the T-test result for the hydrogen energy dimension shows T =−3.094 with P = 0.001, indicating a statistically significant difference in attitudes towards the use of hydrogen energy. This difference is in favor of Batna University students, who exhibited more positive attitudes towards hydrogen energy, with a mean score of 27.0081 (Std. Deviation = 3.20986) compared to Oran University students, who had a mean score of 25.4699 (Std. Deviation = 3.89289), respectively. The significant P-value suggests that the observed difference in attitudes is unlikely to be due to chance.

• Overall Questionnaire

Considering the questionnaire as a whole, the T-test result (T =−2.956, P = 0.002) revealed significant differences in students' attitudes towards the use of hydrogen energy, again in favor of Batna University students. The total mean score for Oran University students was 38.8313 (Std. Deviation = 5.09380), while for Batna University students it was 40.8699 (Std. Deviation: 4.68860). This significant difference underscores the more favorable attitude towards hydrogen energy among students from Batna University.

In summary, while there was no significant difference in attitudes towards renewable energy in general between the two universities, there was a notable and statistically significant difference in attitudes towards hydrogen energy, with Batna University students showing more positive attitudes. This distinction is important for understanding the specific areas of renewable energy that may require more focused educational or advocacy efforts, particularly for promoting the benefits and potential of hydrogen energy among students. Including the means and standard deviations provides a clearer picture of the data distribution and magnitude of differences between the groups, enhancing the depth of our analysis.

To determine if there were differences in the attitudes of health and safety students towards the use of hydrogen energy based on their gender, we used an independent-sample t-test, as illustrated in Table 6.

Table 6. Differences in students' attitudes based on gender.

	Gender	N	Mean	Std. Deviation	Df	T	Sig
Renewable energy	Male	120	13,4667	2,15739	204	-,962	,169
	Female	86	13,7442	1,86728			
Hydrogen energy	Male	120	26,4417	3,43437	204	,252	,400
	Female	86	26,3140	3,77690			
Total	Male	120	39,9917	4,95949	204	-,194	,423
	Female	86	40,1279	4,95580			

Looking at the table, we can observe that for the first dimension (T =-,962 / p =,169), there are no significant differences in the use of renewable energy dimension, in addition to the second dimension (T =,252/p =.400), which also indicates no significant differences in the use of hydrogen energy dimension. For the questionnaire we found (T =-,194 / p =,423), there were no significant differences in students' attitudes toward the use of hydrogen energy, so there were no significant differences between males and females considering the two dimensions (renewable energy, hydrogen energy) for the total result.

The analysis presented in Table 6 explores whether gender influences students' attitudes towards renewable and hydrogen energy. Utilizing the independent-sample t-test, we examined differences in attitudes based on gender across two dimensions: renewable energy and hydrogen energy, as well as overall attitudes combining both dimensions.

• Renewable Energy Dimension
• Males: mean = 13.4667, Std. Deviation = 2.15739
• Females: mean = 13.7442, Std. Deviation = 1.86728
• T-test Result: T =−0.962, P = 0.169

The T-test result for the renewable energy dimension indicated no statistically significant difference in attitudes between male and female students (p = 0.169). This suggests that both genders have similar attitudes towards renewable energy, as the P-value exceeds the commonly used significance level of α= 0.05.

• Hydrogen Energy Dimension
• Males: Mean = 26.4417, Std. Deviation = 3.43437
• Females: mean = 26.3140, Std. Deviation = 3.77690
• T-test Result: T = 0.252, P = 0.400

Similarly, the T-test result for the hydrogen energy dimension showed no significant difference in attitudes between genders (P = 0.400). This indicates that male and female students share comparable attitudes towards hydrogen energy.

• Overall Attitudes:
• Males: mean = 39.9917, Std. Deviation = 4.95949
• Females: mean = 40.1279, Std. Deviation = 4.95580
• T-test Result: T =−0.194, p = 0.423

When considering the total attitudes towards both renewable and hydrogen energy, the t-test again revealed no significant difference between male and female students (P = 0.423). This further supports the conclusion that gender does not significantly influence students' attitudes towards these forms of energy.

In summary, the independent-sample t-test analysis across both specific energy dimensions and overall attitudes demonstrates that there are no significant differences between male and female students' attitudes towards renewable and hydrogen energy. This finding suggests that gender does not play a decisive role in shaping student perceptions and attitudes in this context. This revised comment provides a more detailed breakdown of the results, including specific means and standard deviations for each sex, which adds depth to the analysis. It also reiterates the significance level (α) used to interpret the P-values, clarifying the basis for determining statistical significance.

The ANOVA test results presented in Table 7 aim to explore differences in attitudes towards renewable and hydrogen energy among health and safety students across various levels of education. Each area was analyzed based on the Sum of Squares, Degrees of Freedom (Df), Mean Square, F-value, and Significance (Sig.).

Table 7. Results of ANOVA between the groups.

		Sum of Squares	Df	Mean Square	F	Sig.
Renewable Energy	Between Groups	20,087	4	5,022	1,210	,308
	Within Groups	834,010	201	4,149		
	Total	854,097	205			
Hydrogen Energy	Between Groups	81,857	4	20,464	1,623	,170
	Within Groups	2535,075	201	12,612		
	Total	2616,932	205			
Total	Between Groups	184,143	4	46,036	1,915	,109
	Within Groups	4831,372	201	24,037		
	Total	5015,515	205			

• For Renewable Energy, the F-value of 1.210 and p-value of 0.308 suggest that differences in attitudes towards renewable energy among the different education levels are not statistically significant.

• For Hydrogen Energy, the F-value was slightly higher at 1.623, with a p-value of 0.170. Similar to renewable energy, these results indicate no significant differences in attitudes based on the educational level.

• The Total category, which combined attitudes towards both renewable and hydrogen energy, showed an F-value of 1.915 and a p-value of 0.109. Again, this confirms the lack of statistically significant differences between the groups.

The ANOVA test results indicate that there are no statistically significant differences in the attitudes of health and safety students towards renewable and hydrogen energy, based on their level of education (Figure 3). All p-values exceeded 0.05 (Weiss, 2006).

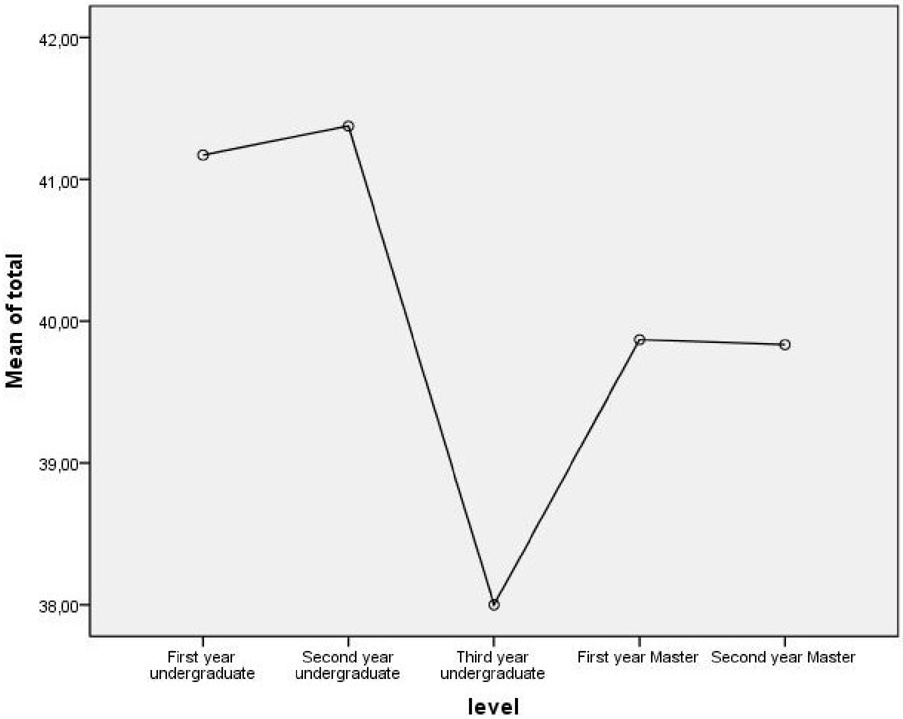

Figure 3. Line graph showing the mean total scores by academic level.

Discussion

The primary goal of this study was to evaluate the attitudes of health and safety engineering students towards hydrogen energy as a renewable energy source. And for that we prepared a questionnaire that consisted of two dimensions ‘the use of renewable energy’ and ‘the use of hydrogen energy,’ it was distributed randomly on 206 students, both male and female from two different universities, university of Batna in the east of Algeria, university of Oran 2 located in the west of Algeria where we have confirmed the reliability and validity of the questionnaire Table 2 and Table 3.

From Table 4 attitudes of health and safety engineering students towards the use of hydrogen as a renewable source are acceptable. For the results from Table 5 we confirmed that the T-test was insignificant considering the first dimension, which may be due to the fact that renewable energy has become a subject most of engineer students aware of, especially solar energy that is the moment's talk due the huge surface of desert in Algeria and the new projects that are being launched and the desire to work in one of these big companies, which matches the results found in the study of Fatih Aydın (Fatih Aydın & Ali Osman Kocalar, 2014), for the results of questionnaire. Our study revealed that the attitudes of health and safety engineering students towards hydrogen energy are significantly influenced by their educational experiences, as we found significant differences in students attitudes toward the use of hydrogen energy in favor of Batna's potentially due to their professors' practical engineering backgrounds, and professors with hands-on industry backgrounds are often able to bridge the gap between theoretical knowledge and real-world applications. Their teaching likely included practical examples, case studies, and insights from ongoing engineering projects involving renewable energy technologies, including hydrogen. This approach can enhance students' understanding of the technical feasibility, economic viability, and environmental benefits of hydrogen energy, making the concept more tangible and credible in their eyes. Professors with practical experience tend to emphasize problem-solving skills and innovation, encouraging students to critically engage with emerging energy technologies, and also a curriculum that includes renewable energy topics. This aligns with findings from Fatih Aydın and Ali Osman Kocalar's study (Fatih Aydın & Ali Osman Kocalar, 2014), suggesting that practical exposure and curriculum content play crucial roles in shaping student attitudes and that they influence students by accepting all types of renewable energy, such as hydrogen energy (green hydrogen). Furthermore, interestingly, the results of the t-test in Table 6, interestingly our results indicated no significant differences in attitudes based on gender. This may reflect the uniformity of the educational curriculum from elementary through university levels, which both genders experience similarly. This could be influenced by the specific demographic and cultural context of our sample, which might be more homogeneous or balanced in terms of education and exposure to renewable energy issues. measurement instruments, and the dimensions of the attitudes assessed may capture aspects where gender differences are less pronounced. Finally, Table 7 illustrates the ANOVA test results between the groups, indicating no statistically significant differences between academic levels. Upon reviewing the programs, we discovered that from the first year to the last year, no courses or subjects on green hydrogen were taught at either university. As a result, students receive no information or principles that could contribute to their knowledge in this area (Figure 3). Hydrogen energy is not widely applicable or relevant in the region, a completely new endeavor in Algeria and around the world, and the production and quantity of green hydrogen are very limited for many reasons, such as infrastructure, cost, and other reasons (Nazir et al., 2020), all of which could contribute to the lack of differences between academic levels. If the subject matter is not integrated into the curriculum or relevant to the local context, students across different academic levels might not receive instruction or exposure to it, which goes along with what has been said in the study of Alawin (Alawin et al., 2016), The lack of differences between academic levels could also be attributed to a lack of information or awareness among professors about renewable energy and specifically hydrogen energy, taking into account the fact that the lack of information affects their attitudes (Genç & Akilli, 2019), which also influences the students (Derasid et al., 2021). The lack of statistical significance across different levels of education suggests that other factors may influence students' attitudes towards hydrogen and renewable energy. While the presentation of p-values clearly indicates no significant differences in attitudes toward renewable energy by gender or academic level, providing a more contextual interpretation enriches the understanding of these results. In the context of Algeria's renewable energy development, these findings may be somewhat unexpected, as the academic level often correlates with environmental awareness, and gender differences have been documented in other regions. However, Algeria's unique sociocultural environment and recent national efforts to promote renewable energy awareness across all segments of society might contribute to a more uniform attitude distribution. Future research could explore additional variables that might impact these attitudes, such as personal values, environmental awareness, and practical experiences with these energy sources.

A health and safety engineering student who lacks sufficient knowledge about hydrogen energy and its associated technologies would likely face challenges in accurately identifying risks and ensuring safety within the hydrogen industry. Understanding the specific risks, safety protocols, and potential hazards related to hydrogen is crucial for effectively managing safety in environments where hydrogen is produced, stored, or utilized. Without proper knowledge, the ability to assess and mitigate potential dangers could be compromised, leading to increased safety concerns within the industry. Our findings underscore the need for educational reforms that incorporate renewable energy topics, particularly hydrogen energy, into the engineering curricula. Future research should focus on curriculum development to integrate practical and hands-on experiences with hydrogen energy, such as laboratory work, project-based learning, and industry internships, as well as interdisciplinary content covering environmental, economic, and policy aspects. This approach can enhance students' understanding of and engagement with hydrogen technology. Additionally, future studies should adopt mixed-methods designs, combining quantitative surveys with qualitative tools, such as interviews or focus groups, to capture deeper insights into student attitudes. Longitudinal research tracking changes before and after educational interventions, as well as comparative studies across different universities, would further enrich our understanding and help tailor effective educational strategies to promote hydrogen energy acceptance. Such integration would not only enhance student knowledge and attitudes, but also align with Algeria's national hydrogen roadmap and its ambition to supply Europe with clean hydrogen. As the industry grows, so too must our educational approaches ensure a well-informed and safety-conscious engineering workforce. This study had several limitations that should be acknowledged. First, the sample was limited to students from only two universities, which may not fully represent the attitudes of all health and safety engineering students in Algeria. Additionally, the sampling method may have introduced a selection bias, as participation was voluntary and could have attracted students already interested in renewable energy topics. The cross-sectional design also limited the ability to assess changes in attitudes over time. These factors suggest caution when generalizing our results to a broader population. Future research with larger, more diverse samples and longitudinal designs would help validate and extend these findings.

Conclusion

Hydrogen is the key to achieving zero emissions while simultaneously tackling many challenges. Extending beyond environmental considerations, we aimed to understand the attitudes of health and safety engineering students towards hydrogen energy based on gender, level, and university. The results showed a medium attitude with no significant differences according to gender and level, but differences in favor of the university of Batna Mostefa Ben Boulaid. We recommend educational programs to highlight the importance of hydrogen energy, its role in sustainability, and the potential career opportunities in the field, especially for the University of Oran, providing students with more information that can lead to increased interest and support. In addition, organizing seminars, workshops, and training programs in universities or private institutes that connect engineering students with professionals in the renewable energy and hydrogen energy industries can be useful for assessing students' attitudes to track changes and influences.

References

Abada, Z., & Bouharkat, M. (2018). Study of management strategy of energy resources in Algeria. *Energy Reports*, *4*, 1–7. https://doi.org/10.1016/j.egyr.2017.09.004

Abbasi, K. R., Shahbaz, M., Zhang, J., Irfan, M., & Alvarado, R. (2022). Analyze the environmental sustainability factors of China: The role of fossil fuels and renewable energy. *Renewable Energy*, *187*, 390–402. https://doi.org/10.1016/j.renene.2022.01.066

Abohamzeh, E., Salehi, F., Sheikholeslami, M., Abbassi, R., & Khan, F. (2021). Review of hydrogen safety during the storage, transmission, and application processes. *Journal of Loss Prevention in the Process Industries*, *72*, Artigo 104569. https://doi.org/10.1016/j.jlp.2021.104569

Alawin, A. A., Rahmeh, T. A., Jaber, J. O., Loubani, S., Dalu, S. A., Awad, W., & Dalabih, A. (2016). Renewable energy education in engineering schools in Jordan: Existing courses and levels of awareness of senior students. *Renewable and Sustainable Energy Reviews*, *65*, 308–318. https://doi.org/10.1016/j.rser.2016.07.003

Apak, S., Atay, E., & Tuncer, G. (2017). Renewable hydrogen energy and energy efficiency in Turkey in the 21st century. *International Journal of Hydrogen Energy*, *42*(4), 2446–2452. https://doi.org/10.1016/j.ijhydene.2016.05.043

Assali, A., Khatib, T., & Najjar, A. (2019). Renewable energy awareness among future generations in Palestine. *Renewable Energy*, *136*, 254–263. https://doi.org/10.1016/j.renene.2019.01.007

Bach, W. (1981). Fossil fuel resources and their impact on the environment and climate. *International Journal of Hydrogen Energy*, *6*(2), 185–201. https://doi.org/10.1016/0360-3199(81)90007-0

Barrett, M., Lowe, R., Oreszczyn, T., & Steadman, P. (2008). Support for growth with less energy. *Energy Policy*, *36*(12), 4592–4599. https://doi.org/10.1016/j.enpol.2008.09.065

Blal, M., Belasri, A., Benatillah, A., Hamouda, M., Lachtar, S., Sahouane, N., Laribi, S., & Mostefaoui, M. (2018). Assessment of solar and wind energy as a motive for potential hydrogen production in Algeria and development of a methodology for using hydrogen-based fuel cells. *International Journal of Hydrogen Energy*, *43*(19), 9192–9210. https://doi.org/10.1016/j.ijhydene.2018.03.200

Boakye, M. K., & Adanu, S. K. (2022). On-site building construction workers' perspective on environmental impacts of construction-related activities: A relative importance index (RII) and exploratory factor analysis (EFA) approach. *Sustainable Environment*, *8*(1), Artigo 2141158. https://doi.org/10.1080/27658511.2022.2141158

Boslaugh, S. (2013). *Statistics in a nutshell* (2nd ed.). O'Reilly Media.

Boudries, R., & Dizene, R. (2008). Potential of hydrogen production in Algeria. *International Journal of Hydrogen Energy*, *33*(17), 4476–4487. https://doi.org/10.1016/j.ijhydene.2008.06.050

Bouraiou, A., Necaibia, A., Boutasseta, N., Mekhilef, S., Dabou, R., Ziane, A., Sahouane, N., Attoui, I., Mostefaoui, M., & Touaba, O. (2020). Status of renewable energy potential and utilization in Algeria. *Journal of Cleaner Production*, *246*, Artigo 119011. https://doi.org/10.1016/j.jclepro.2019.119011

Bouznit, M., Pablo-Romero, M. del P., & Sánchez-Braza, A. (2020). Measures to promote renewable energy for electricity generation in Algeria. *Sustainability*, *12*(4), Artigo (1468). https://doi.org/10.3390/su12041468

Derasid, N. A. C., Tahir, L. M., Musta'amal, A. H., Abu Bakar, Z., Mohtaram, N., Rosmin, N., & Ali, M. F. (2021). The influence of leadership and organizational culture on employee commitment in the renewable energy sector. *Energy Reports*, *7*, 3410–3427. https://doi.org/10.1016/j.egyr.2021.05.031

Djurisic, V., Smolovic, J. C., Misnic, N., & Rogic, S. (2020). Analysis of public attitudes and perceptions of renewable energy sources in Montenegro. *Energy Reports*, *6*, 395–403. https://doi.org/10.1016/j.egyr.2020.08.059

Eshiemogie, S. O., Ighalo, J. O., & Banji, T. I. (2022). Knowledge, perception, and awareness of renewable energy by engineering students in Nigeria: A need for undergraduate engineering program adjustment. *Cleaner Engineering and Technology*, *6*, Artigo 100388. https://doi.org/10.1016/j.clet.2021.100388

Farrell, A. E., Keith, D. W., & Corbett, J. J. (2003). Strategy for introducing hydrogen for transportation. *Energy Policy*, *31*(13), 1357–1367. https://doi.org/10.1016/S0301-4215(02)00195-7

Fatih, A., & Ali, O. K. (2014). The attitudes of the students of geography department toward renewable energy sources. *International Journal of Academic Research*, *9*(3), 389–397.

Freris, L. L., & Infield, D. G. (2020). *Renewable energy in power systems* (2nd ed.). Wiley.

Genç, M., & Akilli, M. (2019). Correlation between renewable energy knowledge and attitude: A structural equation model with future educators. *Journal of Baltic Science Education*, *18*(6), 866–879. https://doi.org/10.33225/jbse/19.18.866

Harrouz, A., Belatrache, D., Boulal, K., Colak, I., & Kayisli, K. (2020). Social acceptance of renewable energy dedicated to electric production. In (2020) *9th International Conference on Renewable Energy Research and Applications (ICRERA)* (pp. 314-318). IEEE. https://doi.org/10.1109/ICRERA49962.2020.9242904

Häußermann, J. J., Maier, M. J., Kirsch, T. C., Kaiser, S., & Schraudner, M. (2023). Social acceptance of green hydrogen in Germany: Building trust through responsible innovation. *Energy, Sustainability and Society*, *13*(1), Artigo 22. https://doi.org/10.1186/s13705-023-00394-4

Hollander, M., Wolfe, D. A., & Chicken, E. (2015). *Nonparametric statistical methods* (3rd ed.). Wiley. https://doi.org/10.1002/9781119196037

Joshi, R. M. (2024). Nexus of gender and renewable energy: Importance and trends in global and national context. *Research and Development Journal*, *4*(1), 1-15. https://doi.org/10.3126/rdj.v4i1.64030

Karatepe, Y., Neşe, S. V., Keçebaş, A., & Yumurtacı, M. (2012). The levels of awareness and knowledge of university students on renewable energy sources: Case study for University of Muğla. *Renewable Energy*, *44*, 174–179. https://doi.org/10.1016/j.renene.2012.01.099

Kempf Leonard, K. (Ed.). (2005). *Encyclopedia of social measurement*. Elsevier Academic Press.

Khan, M. J., & Iqbal, M. T. (2005). Dynamic modeling and simulation of a small wind–fuel cell hybrid energy system. *Renewable Energy*, *30*(3), 421–439. https://doi.org/10.1016/j.renene.2004.05.013

Kirch, W. (2008). Correlation coefficient. In *Encyclopedia of Public Health* (pp. 115–119). Springer. https://doi.org/10.1007/978-0-387-32833-1_83

Li, X., Raorane, C. J., Xia, C., Wu, Y., Tran, T. K. N., & Khademi, T. (2023). Latest approaches to green hydrogen as a potential source of renewable energy for sustainable energy: Spotlighting recent innovations, challenges, and future insights. *Fuel*, *334*, Artigo 126684. https://doi.org/10.1016/j.fuel.2022.126684

McCay, M. H., & Shafiee, S. (2020). Hydrogen. In T. M. Letcher (Ed.), *Future Energy* (pp. 475–493). Elsevier. https://doi.org/10.1016/B978-0-08-102886-5.00022-0

Meeker, W. Q., Escobar, L. A., & Pascual, F. G. (2022). *Statistical methods for reliability data* (2nd ed.). Wiley.

Mraoui, A., & Menia, S. (2019). Renewable electrolytic hydrogen potential in Algeria. *International Journal of Hydrogen Energy*, *44*(49), 26863–26873. https://doi.org/10.1016/j.ijhydene.2019.08.134

Nazir, H., Muthuswamy, N., Louis, C., Jose, S., Prakash, J., Buan, M. E. M., Flox, C., Chavan, S., Shi, X., Kauranen, P., Kallio, T., Maia, G., Tammeveski, K., Lymperopoulos, N., Carcadea, E., Veziroglu, E., Iranzo, A., & Kannan, A. M. (2020). Is the H2 economy possible in the foreseeable future? Part III: H2 usage technologies, applications, challenges, and opportunities. *International Journal of Hydrogen Energy*, *45*(53), 28217–28239. https://doi.org/10.1016/j.ijhydene.2020.07.256

Nnabuife, S. G., Oko, E., Kuang, B., Bello, A., Onwualu, A. P., Oyagha, S., & Whidborne, J. (2023). Prospects of hydrogen in achieving net-zero emissions by 2050: A critical review. *Sustainable Chemistry for Climate Action*, *2*, Artigo 100024. https://doi.org/10.1016/j.scca.2023.100024

Ogden, J. M. (1999). Prospects for building hydrogen energy infrastructure. *Annual Review of Energy and the Environment*, *24*(1), 227–279. https://doi.org/10.1146/annurev.energy.24.1.227

Perera, F., & Nadeau, K. (2022). Climate change, fossil fuel pollution, and children's health. *New England Journal of Medicine*, *386*(24), 2303–2314. https://doi.org/10.1056/NEJMra2117706

Perera, F. P. (2017). Multiple threats to child health from fossil fuel combustion: Impacts of air pollution and climate change. *Environmental Health Perspectives*, *125*(2), 141–148. https://doi.org/10.1289/EHP299

Rahmouni, S., Settou, N., Negrou, B., Chennouf, N., & Ghedamsi, R. (2015). Prospects and analysis of hydrogen production from renewable electricity sources in Algeria. In I. Dincer, C. O. Colpan, O. Kizilkan, & M. A. Ezan (Eds.), *Progress in Clean Energy, Volume 2* (pp. 583–602). Springer. https://doi.org/10.1007/978-3-319-17031-2_42

Reddy, S. N., Nanda, S., Vo, D. V. N., Nguyen, T. D., Nguyen, V. H., Abdullah, B., & Nguyen-Tri, P. (2020). Hydrogen: Fuel in the near future. In *New Dimensions in Production and Utilization of Hydrogen* (pp. 1–20). Elsevier. https://doi.org/10.1016/B978-0-12-819553-6.00001-5

Shafiee, S., & Topal, E. (2009). When do fossil fuel reserves diminish? *Energy Policy*, *37*(1), 181–189. https://doi.org/10.1016/j.enpol.2008.08.016

Singh, S., Jain, S., Ps, V., Tiwari, A. K., Nouni, M. R., Pandey, J. K., & Goel, S. (2015). Hydrogen: Sustainable fuel for the future of the transportation sector. *Renewable and Sustainable Energy Reviews*, *51*, 623–633. https://doi.org/10.1016/j.rser.2015.06.040

Szakály, Z., Balogh, P., Kontor, E., Gabnai, Z., & Bai, A. (2020). Attitude toward and awareness of renewable energy sources: Hungarian experience and special features. *Energies*, *14*(1), Artigo 22. https://doi.org/10.3390/en14010022

Trout, K., Muttitt, G., Lafleur, D., Van De Graaf, T., Mendelevitch, R., Mei, L., & Meinshausen, M. (2022). Existing fossil fuel extraction would warm the world beyond 1.5°C. *Environmental Research Letters*, *17*(6), Artigo 064010. https://doi.org/10.1088/1748-9326/ac6228

Vik, P. (2013). *Regression, ANOVA, and the general linear model: A statistics primer*. SAGE Publications.

Weiss, D. J. (2006). *Analysis of variance and functional measurement: A practical guide*. Oxford University Press.

Wright, K. L. (2013). *An introduction to Cronbach's α: It's the GLM (again)!* Apresentação no Annual Meeting of Southwest Educational Research Association, San Antonio, TX. https://doi.org/10.13140/2.1.1816.8328

Yolcan, O. O. (2023). Future prospects of green hydrogen in achieving net-zero: A review of global strategies and challenges. *Innovation and Green Development*, *2*(4), Artigo 100070. https://doi.org/10.1016/j.igd.2023.100070

Zakaria, S. U., Basri, S., Kamarudin, S. K., & Majid, N. A. A. (2019). Public awareness analysis on renewable energy in Malaysia. *IOP Conference Series: Earth and Environmental Science*, *268*(1), Artigo 012105. https://doi.org/10.1088/1755-1315/268/1/012105

Zhang, F., Zhao, P., Niu, M., & Maddy, J. (2016). Survey of key technologies for hydrogen energy storage. *International Journal of Hydrogen Energy*, *41*(33), 14535–14552. https://doi.org/10.1016/j.ijhydene.2016.05.293