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Attitudes Toward Chemistry Laboratory: A Survey of Indonesian Undergraduate Students

Irwanto IRWANTO[1], Ucu CAHYANA[2], I Wayan REDHANA[3], Jeongho CHA[4], Rudi Suhartono WIJAYAKO[5] and Binar Kurnia PRAHANI[6]

Abstract

This study seeks to examine and compare the attitudes of students towards chemistry laboratory activities, while also investigating the impact of both grade levels and gender on these attitudes. A total of 226 undergraduate chemistry students from a public university in Indonesia participated in the study, selected through convenience sampling. The researchers developed the Attitudes toward Chemistry Laboratory Scale (ACLS) to collect the necessary data. Statistical analyses including ANOVA, t-tests, and descriptive statistics were conducted. The results indicated that: (i) students have positive attitudes toward chemistry laboratory, (ii) significant gaps exist when students' scores on attitudes are linked with gender in favor of male students, and grade levels in favor of students in the junior level, and (iii) no significant interaction effect between gender and grade levels was observed, even though separately, gender mainly effects on students' attitudes. The results contribute significantly to the effectiveness of the chemistry learning process at the tertiary level. By knowing the students' initial attitudes, lecturers are expected to apply various teaching methods that can develop students' positive attitudes and performance to a satisfactory level.

Keywords: *Attitudes Toward Chemistry Laboratory, Gender, Grade Levels, Interaction Effect, Undergraduate Students*

INTRODUCTION

Attitudes, as a part of the affective domain, are an aspect to improve in the curriculum of chemistry teaching for higher education level. Gardner (1975) defined attitudes as a disposition that is used to evaluate certain objects, persons, actions, and situations that relate to the teaching of science in a certain way. Specifically, Cheung (2009) stated that the attitudes show in the form of chemistry itself, chemist, chemistry subject, and chemistry topics as well as research on chemistry teaching. According to Osborne (2003) attitudes encompass feelings, beliefs, and values towards specific objects, influenced by science education, schooling, and the application of science in society. In a study by Brown et al. (2015), attitudes are defined as inclinations to react to a particular stimulus within the realm of chemistry, with responses encompassing cognitive, affective, and behavioral aspects.

Attitudes are a key element for success in STEM education, especially in chemistry teaching and learning activities. Some quantitative studies (e.g., Brown et al., 2015; Cheung, 2009; Hofstein & Mamlok-Naaman, 2011; Kubiatko et al., 2017; Kurbanoglu & Akin, 2010) investigating the effect of attitudes toward chemistry have been conducted at various education levels. In general, the results of those studies suggest that educators start to improve students' attitudes toward chemistry at an earlier age and include it as a basic competence to master. Kan and Akbas (2006) have measured the influence of attitudes toward chemistry on 1000 high school students, which result indicates a positive association between affective and academic achievement. In relation to the importance of improvement in students' attitudes toward chemistry, Kurbanoglu and Akin (2010) pointed out

[1] Ph.D; Universitas Negeri Jakarta, Department of Chemistry Education, Jakarta 13220, Indonesia, E-mail: irwanto@unj.ac.id, ORCID: 0000-0001-5842-5931

[2] Prof. Dr.; Universitas Negeri Jakarta, Department of Chemistry Education, Jakarta 13220, Indonesia. E-mail: ucahyana@unj.ac.id, ORCID: 0000-0001-7401-1069

[3] Prof. Dr.; Universitas Pendidikan Ganesha, Department of Chemistry, Bali 81116, Indonesia. E-mail: wayan.redhana@undiksha.ac.id, ORCID: 0000-0002-0803-8199

[4] Prof. Dr.; Daegu University, South Korea, E-mail: daniel.jh.cha@gmail.com

[5] National Research and Innovation Agency, Jakarta, Indonesia. E-mail: rudi022@brin.go.id, ORCID: 0009-0009-1211-7939

[6] Ph.D.; Universitas Negeri Surabaya, Surabaya, Indonesia, Email: binarprahani@unesa.ac.id

two major reasons why the improvement matters. First, it has been known that attitudes and academic achievement are inter-correlated. Second, attitudes predict students' behavior in teaching and learning activities. Therefore, it is necessary that lecturers create favorable teaching and learning environment that supports students to grow positive attitudes toward chemistry.

Previous studies showed that attitudes have certain influences on some other variables such as self-efficacy (Kundu & Ghose, 2016; Kurbanoglu & Akin, 2010; Senler, 2016), problem-solving (Demirel et al., 2015; Marchis, 2013), and achievement (Cheung, 2009; Salta & Tzougraki, 2004; Yuksel & Geban, 2014). In their study, Brown et al. (2015) investigated undergraduate students' attitudes toward chemistry enrolled in an introductory chemistry course. They discovered a slight positive correlation between the affective scores of students and their academic achievement, particularly among those classified as low-achieving students. On the other hand, no correlation was found in the group of students with high achievement. Meanwhile, Yuksel and Geban (2014) investigated the correlation between chemistry learning and attitudes toward chemistry among 252 students from a vocational high school in Turkey. They observed a significant link between these variables. A similar result was also confirmed by Brandriet et al. (2011) who also confirmed a positive correlation between students' attitudes and success in general chemistry.

Previous studies have also identified various factor that influence students' attitudes including gender (e.g., Can, 2012; Heng & Karpudewan, 2015) and grade levels (e.g., Can, 2012; Heng & Karpudewan, 2015). In Malaysia, Heng and Karpudewan (2015), for instance, found gender and grade level significantly influence students' attitudes toward chemistry learning. Moreover, they noted that there is a significant interaction effect between gender and grade level on secondary school students' chemistry attitudes. Similarly, in Turkey, Can (2012) reported a statistically significant influence of the interaction between grade level and gender on attitudes toward chemistry of students across grades 9 to 11.

On the other side, contradictory findings were found in previous studies, which stated that attitudes are not influenced by gender (Barrington & Hendricks, 1988; Nasr & Soltani, 2011; Reddy, 2017; Sorge, 2007) and grade levels (Matthews, O'Neill, & Kostelis, 2014; Ozyurek & Eryilmaz, 2001; Saif & Asiri, 2017; Simpson & Steve Oliver, 1990). In South Africa, Reddy (2017) reflected on the nature of 547 seventh graders' attitudes toward science and found no significant gap in students' science attitudes concerning gender. Another study conducted by Kubiatko et al. (2017) in which an investigation was administered to 931 students in Czech schools, found that gender and grade level showed to have no significant influence on students' attitudes toward chemistry. However, they reported that female students from grades 8-10 tend to have more positive attitudes toward chemistry, while higher scores were obtained by male students from grades 11-12. A study that took place in Saudi Arabia, conducted by Saif and Asiri (2017) analyzed the attitudes of 95 elementary school students toward science which result found no significant correlation between them. The influences of gender and grade levels on various research variables remain debatable. In this study, the researchers expected to find significant gaps among those factors and it is also expected that students' attitudes toward chemistry improve linearly to higher levels.

Some previous studies proposed that the correlation between students' attitudes and academic performance can predict students' academic achievement. Kubiatko et al. (2017) believed that students exhibiting positive chemistry attitudes tend to achieve better academic results compared to those with negative attitudes. In addition, in this study, the researchers view attitudes as one of the essential domains that share a certain relationship with the learning environment. A previous study conducted by Abdullah et al. (2007) examined the impact of microscale chemistry experimentation on attitudes towards practical work in chemistry. Sesen and Tarhan (2010) investigated the effect of constructivism-oriented active pedagogy on students' learning achievement and attitudes toward chemistry. Tuysuz (2010) tried to enhance students' achievement and attitudes toward chemistry using virtual laboratory teaching. Whilst, Saribas and Bayram (2009) improved students' scientific process skills and chemistry attitudes by fostering their metacognitive skills in the chemistry laboratory. They claimed that the learning environment plays a positive role in influencing students' chemistry attitudes.

The Aim of the Research

Our study focused on understanding undergraduate students' attitudes toward chemistry laboratories in Indonesia in consideration of the fact that available studies are limited to only exploring scientific attitudes (e.g., Kristiani, Susilo, & Aloysius, 2015; Kususanto, Fui, & Lan, 2012; Schibeci & Fraser, 1987; Suryawati & Osman, 2018; Wahyudi & Treagust, 2001). Whereas, positive attitudes toward chemistry laboratory are actually an essential aspect that should be included into higher education curricula (Brown et al., 2014). In line with this idea, Hacieminoglu (2016) underscored the notable influence of educational level on students' science attitudes. Regarding the aforementioned explanation, this study was intended to: (i) analyze university students' attitudes level, (ii) compare students' attitudes level based on gender and grade level, and (iii) investigate the interaction effect between grade levels and gender on undergraduate students' attitudes towards chemistry laboratory.

METHOD

Research Design

This cross-sectional study adopted an observational research approach, utilizing the survey method to gather data on students' attitudes categorized by gender and grade levels at a particular moment. Pinsonneault and Kraemer (1993) define a survey as a method used to collect information about the characteristics, behaviors, or opinions of a specific group of individuals.

Participants

In the present study, 226 students from the Department of Chemistry served as respondents, comprising freshmen (first-year students; 33.19%), sophomore (second-year; 34.07%), and junior (third-year; 32.74%). All of the respondents have attended General Chemistry Laboratory, Chemical Equilibrium Laboratory, and Chemical Instrument Laboratory courses respectively (see Table 1). The survey was done during the first semester of the 2019-2020 academic year at a public university in Indonesia. The participants were selected using convenience sampling. As defined by Abrams (2010), convenience sampling is used to choose only accessible respondents to participate in a study.

Table 1. Demographic variables frequency

Grade Levels	Female	Male	Total
Freshman	49	26	75
Sophomore	49	28	77
Junior	51	23	74
Total	149	77	226

Instrument and Procedures

In this survey, the Attitudes toward Chemistry Laboratory Scale (ACLS) was designed by the first author to investigate undergraduate students' attitudes toward chemistry in laboratory experiments. The ACLS consisted of 9 subscales reflected in 36 items (18 negative and 18 positive statements). The 9 subscales included aversion to superstition, open-mindedness, curiosity, objectivity, humility, intellectual honesty, suspended judgment, and critical mindedness (i.e., Billey & Zakhariades, 1975; Gauld & Hukins, 1980; Onder, Celik, & Silay, 2012). Each subscale comprised 4 statements (2 items each positive and negative), all measured using a 4-point Likert scale (1 – Strongly Disagree, 2 – Disagree, 3 – Agree, and 4 – Strongly Agree). Negative statements were marked by inverse codes. The score ranged from 36 to 144 pts for each respondent. In a pilot study, the ACLS had been tried out on 145 students majoring in chemistry who were randomly chosen in Yogyakarta, a central region of Indonesia. The Cronbach's α value was calculated at 0.84, showing that the ACLS has been reliable to measure students' attitudes toward chemistry. It should be noted that tudents' attitudes were categorized into three levels; negative (<72 pts), neutral (72 to 108 pts), and positive (>108 pts).

The following statements are examples of ACLS items:

I choose to explore and discover certain natural phenomena

I think laboratory activities help me comprehend how chemistry influences our daily life

I am learning to be a chemist

I do not acknowledge newer and more relevant theories in science

I report experiment data based on the empirical results

I do not feel satisfied if I draw a conclusion before collecting empirical evidence

I would like to make science perfect through chemistry experiments

After obtaining written permission from the ethics committee, the researchers met with respondents to convey the research purposes. At the outset of the study, all respondents signed the consent form. As volunteers, they can withdraw at any time. Then, we distributed the survey to all respondents. The ACLS was completed in about 15 minutes. Our study was conducted in the middle of the semester. It was intended that the findings could take advantage of a recommendation for educators to raise student attitudes to a satisfactory level using a variety of effective learning methods.

Data Analysis

Negative items had been reversely scored before they were statistically analyzed. Two hundred and twenty-six data were included in the analysis. Descriptive statistics, including mean, standard deviation, and percentage, were calculated to understand the data characteristics. Afterward, one-way ANOVA was used to measure the gaps among three groups based on the grade levels. Meanwhile, a *t*-test was administered to check if the two groups based on gender obtained any different mean scores. Simultaneously, two-way ANOVA was employed to examine whether an interaction existed between grade levels and gender regarding students' attitudes toward the chemistry laboratory. The significance level was set at 0.05, and data analysis was performed using SPSS 17.0 (SPSS Inc., USA).

RESULTS

This section presents the result of statistical analysis, showing undergraduate students' attitudes level. Table 2 presents the summary of the nine subscales. Students showed a strong positive attitude in the Intellectual Honesty subscale (M = 13.24, SD = 1.417) and the least positive one in the Suspended Judgment (M = 12.28, SD = 1.147). It is known that students regarded the importance of honesty in writing their laboratory work reports based on the true experiment results. Overall, based on the result of the measurement on the nine subscales, it is known that students have positive attitudes toward chemistry laboratory (M = 115.33, SD = 7.458).

Table 2. Descriptive statistics of students' attitudes toward chemistry laboratory

Subscales	No. of Items	M	SD	Percentage
Curiosity	4	12.78	1.344	79.88
Aversion to superstition	4	12.96	1.307	81.00
Open-mindedness	4	12.93	1.500	80.81
Objectivity	4	13.16	1.291	82.25
Humility	4	12.93	1.325	80.81
Suspended judgment	4	12.28	1.147	76.75
Rationality	4	12.40	1.108	77.50
Intellectual honesty	4	13.24	1.417	82.75
Critical mindedness	4	12.63	1.245	78.94
All subscales	36	115.33	7.458	80.09

Table 3 shows students' attitudes summary based on gender. Generally, male students tended to have higher scores than females, except in the Curiosity and Intellectual Honesty subscales. In those two subscales, female students believe that curiosity is a means to complete their knowledge by conducting a series of experiments. On the other hand, male students (M = 117.31, SD = 7.651) exhibited more positive attitudes towards chemistry laboratory work compared to female (M = 114.30, SD = 7.169). Statistically, a significant gap was found in the scores of attitudes based on gender in the Rationality, Objectivity, and Critical Mindedness subscales in favor of male students. Whereas, in other subscales, the gap was not found.

Table 3. Students' attitudes toward chemistry laboratory based on gender

Subscales	Female		Male		*F*	*p*
	Mean	SD	Mean	SD		
Curiosity	12.78	1.251	12.79	1.516	5.397	0.946
Aversion to superstition	12.84	1.316	13.19	1.267	0.018	0.052
Open-mindedness	12.81	1.421	13.17	1.625	0.402	0.105
Objectivity	12.98	1.205	13.52	1.382	6.157	0.004
Humility	12.83	1.317	13.12	1.328	0.060	0.126
Suspended judgment	12.21	1.112	12.42	1.207	0.498	0.213
Rationality	12.19	0.996	12.82	1.200	2.422	0.000
Intellectual honesty	13.22	1.320	13.29	1.597	5.646	0.762
Critical mindedness	12.44	1.164	13.00	1.318	0.604	0.001

Table 4 presents the summary of students' attitudes level based on grade levels. The findings indicate that junior-level students achieved higher mean scores compared to other grade levels, except in the Suspended Judgment and Humility subscales. Meanwhile, students in the sophomore level tend to have lower scores, except in the Intellectual Honesty subscale, when compared to students in the freshman level. In general, junior-level students (M = 116.53, SD = 7.081) exhibited more positive attitudes towards chemistry laboratory work than sophomore-level (M = 113.62, SD = 7.815) or freshman-level students (M = 115.89, SD = 7.220). This result shows that students explicitly express their dissatisfaction when they have to draw a conclusion before obtaining adequate supporting evidence. Statistically, students' scores on attitudes toward chemistry are significantly different based on students' grade levels in all of the subscales used in this study.

Table 4. Students' attitudes toward chemistry laboratory based on grade levels

Subscales	Freshman		Sophomore		Junior		*F*	*p*
	Mean	SD	Mean	SD	Mean	SD		
Curiosity	12.85	1.440	12.53	1.324	12.97	1.238	2.203	0.113
Aversion to superstition	13.09	1.463	12.69	1.195	13.11	1.223	2.562	0.079
Open-mindedness	13.03	1.568	12.58	1.525	13.20	1.344	3.499	0.032
Objectivity	13.23	1.321	12.94	1.291	13.34	1.242	1.988	0.139
Humility	13.05	1.304	12.86	1.537	12.88	1.097	0.495	0.610
Suspended judgment	12.43	1.176	12.14	1.189	12.28	1.067	1.165	0.314
Rationality	12.39	1.150	12.22	1.131	12.61	1.018	2.344	0.098
Intellectual honesty	13.11	1.247	13.23	1.495	13.39	1.497	0.756	0.471
Critical mindedness	12.72	1.073	12.43	1.473	12.74	1.135	1.516	0.222

Table 5 provides a summary of the interaction effects between gender and grade levels on attitudes of undergraduate students. The result of the data analysis shows that gender significantly influences students' attitudes ($p < 0.05$), while grade levels do not ($p > 0.05$). Furthermore, the interaction between gender and grade levels also lacks significant effects on students' attitudes ($p > 0.05$). This result implies that students' attitudes are only influenced by gender, with neither grade levels nor the interaction between gender and grade levels having any impact on students' attitudes.

Table 5. The interaction effect between gender and grade levels

	Type III Sum of Squares	*df*	Mean Square	*F*	*p*
Gender	478.751	1	478.751	9.258	0.003
Grade level	245.214	2	122.607	2.371	0.096
Gender * grade level	288.554	2	144.277	2.790	0.064

*Note: * interaction*

To see if a significant gap existed between students' attitudes in all grade levels, a Post Hoc analysis (see Table 6) was administered which results show that only students in sophomore and junior levels have significant influences on attitudes toward chemistry laboratory ($p < 0.05$). Students at the sophomore level scored relatively lower than students at the junior level in all of the subscales.

Table 6. Post hoc analysis (bonferroni) across grade levels

	(I) Grade Levels	(J) Grade Levels	Mean Difference (I-J)	Std. Error	*p*
Attitudes toward chemistry laboratory	Freshman	Sophomore	2.27	1.167	0.159
		Junior	-0.63	1.178	1.000
	Sophomore	Freshman	-2.27	1.167	0.159
		Junior	-2.90*	1.171	0.042
	Junior	Freshman	0.63	1.178	1.000
		Sophomore	2.90*	1.171	0.042

Figure 1 shows the change in attitudes between male and female students based on their grade levels. Males tend to have their attitudes improved as they go to higher grade levels. Meanwhile, female students' attitudes tend to decline from junior to sophomore level, even though they made improvements from sophomore to junior level. Overall, the graph shows that female students score lower than their counterparts in all grade levels. It is shown that male students obtain high scores in almost all attitude subscales, except in Intellectual Honesty in which the gap is slightly different. Whilst, at the sophomore level, male students are superior in all of the subscales to female students.

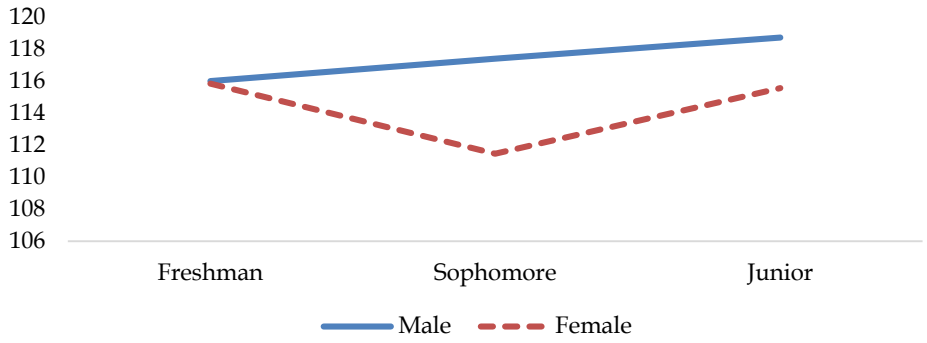

Figure 1. Changes in attitude scores between male and female students in terms of grade levels

DISCUSSION

The research delved into the attitudes of undergraduate students towards chemistry laboratory work, analyzing them according to gender and grade levels, and examining the interaction effect between gender and grade levels on these attitudes. The findings revealed that students generally hold positive attitudes towards chemistry laboratory work. This finding supports previous evidence (e.g., Abdullah et al., 2007; Cheung, 2009; Okebukola, 1986; Tarhan & Sesen, 2010). Similarly, the result is also parallel with research done by Brown et al. (2014) who investigated students' attitudes toward chemistry and found that both first-year undergraduate students generally have positive attitudes toward chemistry. In another study, Yunus and Ali (2013) analyzed 80 secondary school students in Malaysia and found out that the majority of them also show a positive attitude in chemistry classes, especially during experiments in the chemistry laboratory. Slightly differing results were reported by Heng and Karpudewan (2015), who studied 446 secondary school students to assess their attitudes towards chemistry learning in Malaysia. They concluded that students' attitudes tended to be positive.

The result of the two-way ANOVA test conducted in our study shows the indication of a significant influence of gender on students' attitudes toward chemistry laboratory work, while grade levels have an insignificant influence. These findings are supported by previous research. For instance, Cheung (2009) examined the effect of grade level and gender on chemistry attitudes among 954 secondary level chemistry students in grades 4-7 in Hong Kong. They found a major and significant effect of gender on attitudes towards chemistry lessons, with male students tending to exhibit more positive attitudes. Similarly, Heng and Karpudewan (2015) also found that gender significantly influences students' attitudes toward chemistry learning. High scores were mostly obtained by both male and female students from the 5th and the 6th grade. Students' attitudes improved

in the 4th grade to the 5th grade. Furthermore, Can (2012) reported a significant influence of gender on chemistry attitudes, with male students from the 9th grade scoring higher than females in the dimension of Enjoyment and Importance of Attitudes toward Chemistry. In their study, Smith et al. (2014) found that 4th and 8th-grade male students have stronger faith in science than female students, and gender moderates the correlation between science achievement and attitudes toward science. This tendency for male students to exhibit relatively better attitudes towards science subjects, particularly chemistry, may be attributed to their enjoyment of these subjects (Brotman & Moore, 2008; Reddy, 2017).

Indeed, previous studies consistently demonstrate similar findings regarding the attitudes of male and female students towards chemistry. Male students generally exhibit more positive attitudes compared to their female counterparts. For instance, Wan and Lee (2017) discovered that male students displayed significantly more positive science attitudes across various dimensions, including self-concept in science, learning science in and outside the classroom, enjoyment in science, and future participation, compared to female students. Furthermore, Kousa et al. (2018) conducted a study in Finland to assess the chemistry attitudes among students with low achievement. They found that male students tended to have more positive chemistry attitudes than female students within the low-achievement group. Additionally, they observed that students with positive attitudes generally achieved better academic outcomes. These findings underscore the importance of understanding and addressing gender differences in chemistry attitudes to promote equitable learning outcomes for all students.

The findings from a meta-analysis conducted by Weinburgh (1995) examining literature from 1970 to 1991 revealed a consistent trend: male students generally exhibit more positive science attitudes compared to female students. From the literature analysis, it can be seen that male students tend to have more positive science attitudes than female students. Similarly, Osborne (2003), in a review of major literature spanning the past two decades, reported a consistent pattern of male students demonstrating more positive science attitudes than females. Hacieminoglu (2016) suggested that this disparity in attitudes could be attributed to the higher motivation of male students towards science compared to females. Furthermore, Smith et al. (2014) added that male students tend to have stronger confidence and interest in science than their female counterparts. These findings collectively underscore the persistent gender differences in science attitudes observed across various studies over the years.

Within the context of different grade levels, this research shows that different grade level does not influence students' attitudes toward chemistry laboratory work. This finding is supported by Ye et al. (1998), who compared the attitudes of 964 American and Chinese secondary students from grades 7th to 12th. They found that neither grade level nor gender exhibited significant differences among students from the two different countries. Instead, they confirmed that female students generally exhibit weaker science attitudes compared to male students.

In Turkey, Eren et al. (2015) conducted a study involving 247 students from 4th, 5th, and 6th grades, finding no significant gap in students' attitudes toward scientific experiments based on their grade level. Interestingly, 5th-grade students obtained the highest scores in their study. Similarly, Calik, Ultay, Kolomuc, and Aytar (2015) examined the effect of grade level on students' chemistry attitudes in Turkey using the Chemistry Attitudes and Experiences Questionnaires. Their results revealed no statistically significant gaps between the subscales 'chemists' and 'chemistry jobs' based on grade level. Lastly, Metin et al. (2012) investigated the attitudes toward science teaching of prospective elementary teachers, finding no significant differences in students' attitudes based on their grade levels, with no grade level showing a clear advantage.

Previous studies have yielded findings consistent with the results of this research, indicating that students from higher grade levels tend to have more positive chemistry attitudes compared to those from lower grade levels. For instance, Menis (1989) investigated students' attitudes toward school, science, and chemistry, finding that 12th graders exhibited more positive attitudes than 11th graders. Similarly, a study conducted in Turkey by Ozyurek and Eryilmaz (2001) examined the effects of various independent variables on 317 tenth and eleventh-grade science students, revealing no significant differences in attitudes toward physics between students from 10th and 11th grades. Additionally, Akcay et al. (2010) explored changes in the attitudes of 609 students toward

science across grade levels (grades 7 to 9), suggesting that attitudes tend to improve as students progress to higher grade levels. It is speculated that this improvement in attitudes may be attributed to students' increasing knowledge and experience as they engage in more chemistry lessons.

The surprising result of this study, indicating that the interaction between gender and grade levels does not influence attitudes toward chemistry laboratory, is consistent with findings from other previous studies. For example, Calik et al. (2015) also found no statistical gap between the interaction of gender and grade level on students' attitudes. Similarly, Sorge (2007) conducted a study in Mexico involving 1008 elementary and middle school students aged 9 to 14, which revealed no significant influence of gender and age on students' science attitudes. Although some studies, such as those conducted by Can (2012), Cheung (2009), and Heng and Karpudewan (2015), reported that the interaction between gender and grade level significantly influenced students' chemistry attitudes, the result of this research differs. This discrepancy may be attributed to variations in instructional techniques and educational settings used in the teaching of chemistry (Berg, 2005; Hofstein & Mamlok-Naaman, 2011; Okebukola, 1986; Yunus & Ali, 2013). As it is widely recognized, lecturers play a pivotal role in shaping students' chemistry attitudes. Therefore, it is suggested that lecturers enhance students' attitudes through the implementation of research-based teaching, case-based learning, laboratory instructional strategies, and the application of multi-disciplinary approaches to solving complex problems (Abdullah et al., 2007; Adesoji & Raimi, 2004; Basso et al., 2018; Ben-Zvi et al., 1976; Cam & Geban, 2017).

By incorporating these approaches, lecturers can create an engaging and supportive learning environment that fosters positive chemistry attitudes among students, regardless of their gender or grade level. This underscores the importance of pedagogical practices in influencing students' attitudes and highlights the potential for educational interventions to promote positive attitudes toward science subjects like chemistry.

CONCLUSION AND RECOMMENDATIONS

Based on the results of the data analysis in this research, several conclusions can be drawn regarding students' attitudes toward chemistry laboratories. Overall, students exhibit positive attitudes towards chemistry laboratories, with the most positive attitude observed in the Intellectual Honesty subscale and the least positive in Suspended Judgment. When considering gender, male students tend to obtain higher scores than female students, indicating a higher tendency towards positive attitudes among male students. Additionally, students in the junior level tend to have higher attitude scores compared to other levels. Further analysis through Post Hoc tests reveals that only students in sophomore and junior levels show significant influences on their attitudes, suggesting that attitudes may vary significantly between these two grade levels. Moreover, the results of the two-way ANOVA indicate that gender significantly influences students' chemistry attitudes. However, neither grade level nor the interaction between the effects of gender and grade levels has any significant influence on students' chemistry attitudes. Overall, these findings highlight the importance of considering both gender and grade level in understanding students' attitudes towards chemistry laboratories. While male students and those in junior levels tend to exhibit more positive attitudes, other factors such as instructional methods and educational environment may also play a role in shaping chemistry attitudes.

According to the results, it is recommended that lecturers should apply a teaching method that facilitates students to develop positive chemistry attitudes. Lecturers should also implement research-based learning in the teaching of chemistry, in order to allow students to learn to solve various unstructured problems. By engaging students in laboratory activities, it is expected that students grow stronger positive attitudes toward chemistry laboratory. It is also suggested that future researchers should consider expanding the sample size to assess the effects of gender and grade levels on students' attitudes toward chemistry laboratories across different environments and science backgrounds. This can provide more comprehensive insights into the factors influencing chemistry attitudes and inform targeted interventions to promote positive attitudes among diverse student populations.

It is important to acknowledge the limitations of the current study. While the quantitative survey design provided valuable insights into students' attitudes toward chemistry laboratories among 226 undergraduate students at a public university, there are opportunities for further research to enhance the depth and breadth of understanding on the subject. One important avenue for future research could involve expanding the sample

size to include a larger and more diverse population of undergraduate students. This would allow for a more comprehensive analysis of attitudes toward chemistry laboratories across different demographics, academic backgrounds, and institutional settings. Additionally, future studies could benefit from employing mixed-methods approaches that integrate quantitative surveys with qualitative methods such as interviews, observations, and document analysis. By combining multiple data collection techniques, researchers can gain a more holistic understanding of students' attitudes toward chemistry laboratories, including the underlying reasons and contextual factors shaping these attitudes. Overall, conducting further studies with different designs and methodologies can contribute to advancing knowledge and informing best practices in the teaching and learning of chemistry. This can ultimately lead to more effective educational interventions and improved outcomes for students in the field of chemistry.

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