



The GAG Effect: Modelling High School Students' Attitudes Towards Chemistry

Bülent PEKDAĞ¹, Nursen AZİZOĞLU²

¹ Balıkesir University, Necatibey Education Faculty, pekdag@balikesir.edu.tr,
<https://orcid.org/0000-0003-0611-0617>

² Balıkesir University, Necatibey Education Faculty, nursen@balikesir.edu.tr,
<https://orcid.org/0000-0003-0562-9126>

Received: 16.09.2025

Accepted: 23.09.2025

Doi: <https://doi.org/10.37995/jotcsc>.

Abstract: In this study, Turkish high school students' attitudes towards chemistry were examined in terms of Gender-Achievement-Grade level (GAG). The study was conducted with 495 high school students attending the 9th, 10th, 11th, and 12th grades of five different schools in the city of Balıkesir. The "Attitude Scale Towards Chemistry" was used as the data collection tool, and non-parametric statistical analysis methods were employed. As a result, the analyses showed the majority of the students in the sample had positive attitudes towards chemistry, and a statistically significant and positive relationship was found between chemistry achievement and attitudes towards chemistry. Furthermore, statistically significant differences in attitude were detected in terms of gender and grade variables. These results were modeled as GAG effect. Discussion was based on the updated Turkish high school curriculum and international literature. Additionally, recommendations for researchers, teachers, and curriculum designers were presented.

Keywords: GAG effect, attitude, academic achievement, gender, grade level

Corresponding author: Bülent PEKDAĞ, Department of Mathematics and Science Education, Chemistry Education.

INTRODUCTION

The goals of chemistry education are related not only to students' cognition but also to students' affect, an umbrella term for their emotions, feelings, moods, and attitudes (Kahveci, 2015). Based on this idea, providing students with positive attitudes towards chemistry should be an important goal of chemistry education. However, the concept of an attitude towards chemistry is slightly vague, and it is frequently expressed and understood poorly (Brown et al., 2014).

The Concept of Attitude

It is reported that the first person to use the term attitude in 1862 was psychologist Herbert Spencer. Spencer used the term attitude to express the mental state of an individual (Allen et al., 1980). The concept of attitude entered the field of social and behavioural sciences in the early 20th century and its scientific study began at that time (Fleck, 2015). In 1935, Gordon Allport, a well-known American psychologist, stated that attitude was "probably the most distinctive and indispensable" concept in social psychology (Allport, 1935). Since the 1940s in particular, social psychologists have devoted much more time to the formation and change of attitudes than to other topics (McGuire, 1969). The concept of attitude, which is frequently discussed in many different branches of science such as psychology, sociology and education, has been seen as an important concept because it gives an idea about how an individual will behave and allows the individual's behaviour to be understood (McKinlay & McVittie, 2008).

When the literature is examined, it is seen that there are many definitions of the concept of attitude. There is no full consensus on a single definition among researchers who have addressed the subject of attitude. The reason for this is that the definitions emphasize different components of attitude.

Components of Attitude

The concept of attitude has been extensively examined by researchers over the years (Barmby et al., 2008; Reid, 2006). A key consensus is that attitude possesses a multidimensional structure. In line with this, social psychologists proposed the tripartite or ABC model, defining attitude as comprising emotional/affective (A), behavioural (B), and cognitive (C) components (Rosenberg & Hovland, 1960; Wagner & Sherwood, 1969). This model remains the most established framework in social psychology, with Rosenberg and Hovland (1960) being the first to mention this 3-component structure.

The cognitive component encompasses beliefs, knowledge, and thoughts about the attitude object; the affective component reflects emotions and feelings; and the behavioural component denotes the tendency to act verbally or physically towards the object (Eagly & Chaiken, 1998).

Like the cognitive and behavioural components, the emotional/affective component also varies individually and is shaped by past experiences, with cognitive component influencing emotional responses in many cases. However, some attitudes are driven purely by affective component without cognitive mediation. Behavioural component includes tendencies expressed with words and/or actions towards the object (Eagly & Chaiken, 1998).

In conclusion, these three interrelated components—cognitive, affective, and behavioural—create an understanding of an individual's overall attitude, reflecting the integration of beliefs, emotions, and actions towards an object.

Definitions of Attitudes Towards Chemistry

Attitude towards chemistry is defined in various ways in the literature, highlighting its multidimensional nature. Klopfer (1971) focused on acceptance of chemistry knowledge, enjoyment of learning, and interest in chemistry-related activities. Gardner (1975) emphasized emotional aspects such as interest, pleasure, and enjoyment. Osborne, Simon, and Collins (2003) described it more broadly, including feelings, beliefs, and values about school chemistry, chemists, and the societal impact of chemistry. Salta and Tzougraki (2004) viewed attitude as learned positive or negative feelings, while Vishnumolakala et al. (2017) defined it as a general evaluation of chemistry. Cheung (2009a) noted that various elements—such as chemistry itself, chemists, chemistry courses, or industrial chemistry—can serve as attitude objects. Therefore, many studies use “chemistry” as the central attitude object. Overall, these perspectives show that attitude towards chemistry involves both affective and cognitive components and significantly influences student engagement.

According to the tripartite attitude model (ABC attitude model) proposed by social psychologists (Rosenberg & Hovland, 1960; Wagner & Sherwood, 1969), statements such as “learning chemistry will help me pursue a career in medicine” (cognitive component), “I like chemistry” (affective component) and “I read chemistry books” (behavioural component) (Ross et al., 2018) can be considered as attitude expressions towards chemistry. Figure 1 shows the components to be considered in the definition of attitude towards chemistry according to the tripartite attitude model.

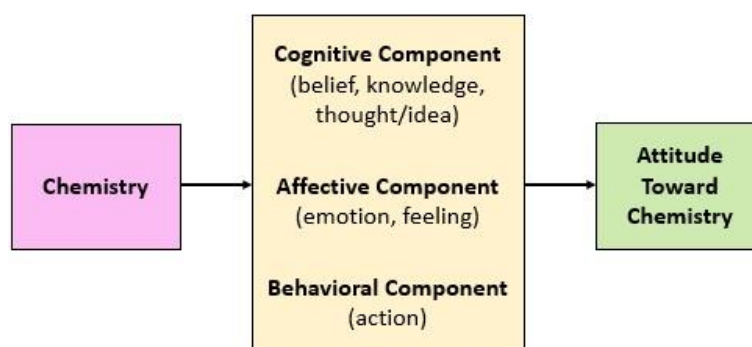


Figure 1

Components to be considered in the definition of attitude towards chemistry (according to the triple/ABC attitude model)

Cheung (2009b), considering the three components indicated in Figure 1, defined attitude towards chemistry lessons in school as liking for chemistry theory lessons and liking for chemistry lab work, evaluative beliefs about school chemistry, and behavioural tendencies to learn chemistry. That is, he conceptualized “attitude to chemistry lessons” as a set of a student’s affective reactions towards, evaluative beliefs about, and behavioural tendencies to the learning of chemistry in school. As can be understood from this conceptualization, the components of attitude are very closely related to each other.

Research Studies on Attitude in Chemistry Education

Research on attitudes towards science education dates back to the 1960s, with seminal works including Dutton and Stephens (1963), Perrodin (1966), and Vitrogon (1967). In recent years, this topic has received increasing attention (Kubiatko et al., 2017; Vilia & Candeias, 2020), highlighting the significance of students’ attitudes towards chemistry in science education.

Attitude levels – low (negative) attitude, medium (neutral) attitude, high (positive) attitude

Adesokan (2000) identified a prevalent negative attitude towards chemistry among Nigerian students. Similarly, Osborne and Collins (2001) reported that British students found certain chemistry topics, such as the periodic table, uninteresting and challenging to memorize. Students also expressed that the subject lacked relevance to their lives or career aspirations. Conversely, practical applications (e.g., mixing chemicals) increased the interest of students who already held positive attitudes towards this aspect of chemistry.

Salta and Tzougraki (2004) found that Greek high school students’ (16-17 years old) attitudes towards the course’s difficulty and interest were neutral. Students viewed chemistry as important for daily life but not useful for future careers. Cheung (2009a) used a four-dimensional attitude scale to assess Hong Kong students’ attitudes towards

chemistry, revealing a slightly positive overall trend. However, a subsequent study (Cheung, 2009b) revealed that 70% of students aged 16-19 did not like chemistry.

Other findings varied by region. Lyons and Quinn (2010) reported positive attitudes among Australian students, driven by perceived career benefits and personal relevance. Xu and Lewis (2011) identified neutral intellectual and emotional attitudes among first-year U.S. university chemistry students. In Turkey, Sezgin Saf (2011) measured neutral attitudes, while Kahveci (2015) also found neutral cognitive and affective attitudes among high school students.

Kubiatko et al. (2017) found that Czech students held positive attitudes towards chemistry and saw it as relevant, but these attitudes declined during their final two years of high school. Similarly, Erökten (2017) reported negative attitudes among Turkish first-year university students enrolled in chemistry courses. In contrast, positive attitudes were identified among Malaysian students aged 16–18 (Ratamun & Osman, 2017). Montes et al. (2018) found that Chilean students displayed slightly higher affective than cognitive attitudes towards chemistry, with overall attitudes remaining neutral.

Despite extensive research spanning decades and nations, a clear consensus regarding students' attitudes towards chemistry has yet to emerge.

Relationship between attitude and academic achievement

Multiple studies confirm a positive relationship between attitude towards chemistry and academic achievement. Xu et al. (2013) demonstrated that positive attitudes correlate with higher achievement in chemistry.

Adesokan (2000) suggested that Nigerian students' negative attitudes stemmed from poor chemistry performance, while Adesoji and Raimi (2004) connected this to low exam scores. Sezgin Saf (2011) indicated that low achievers held negative attitudes, whereas high achievers had positive attitudes. Similarly, Chan and Bauer (2014) found that high chemistry attitudes predicted higher chemistry achievement. In another study, Chan and Bauer (2016) showed that self-esteem and prior knowledge influenced both learning behaviour and exam success, arguing that affective characteristics (attitude, motivation, and chemistry self-concept) shape study habits and performance.

Montes et al. (2018) confirmed that as Chilean students' chemistry grades increased, so did their attitude scores. Oğuz (2020) reported that Turkish students' grade point averages and attitudes were directly proportional. Smith et al. (2020) emphasized that despite complex factors influencing academic achievement, attitude remained a crucial determinant.

In summary, research across various countries consistently demonstrates a significant, positive relationship between attitude and achievement in chemistry.

Relationship between attitude and gender

The influence of gender on attitudes towards chemistry remains inconclusive. Several studies reported that male students held more positive attitudes towards chemistry than females (Brandriet et al., 2011; Vilia & Candeias, 2020). Similar findings emerged in Hong Kong (Cheung, 2009a), the Czech Republic (Kubiatko et al., 2017), and Finland (Kousa et al., 2018).

Conversely, other studies indicated that female students had more positive attitudes (Can & Boz, 2012; Heng & Karpudewan, 2015). Salta and Tzougraki (2004) found no significant gender difference among Greek students, a result also reported by Montes et al. (2018) for Chilean students. Finally, Azizoğlu (2004), Erökten (2017), and Karataş (2020) also found that there was no significant difference in the attitudes of Turkish students towards chemistry according to gender.

Overall, research reveals mixed results, with no clear consensus on the influence of gender on chemistry attitudes.

Relationship between attitude and grade level (age)

Grade level also impacts student attitudes. Ratamun and Osman (2017) found that grade level had a significant effect on the attitudes of Malaysian students (16–18 years) towards chemistry. Cheung (2009a) reported a decline in Hong Kong students' (16–19 years) attitudes with increasing grade level, attributing this to dislike of cookbook-style laboratory work, lack of real-life relevance, and chemistry not being essential for preferred university programs.

Can and Boz (2012) found that grade level significantly affected the attitudes of Turkish students (16–18 years) towards chemistry. While attitude scores fluctuated across grades, an overall decline was observed from 9th to 11th grade in both liking and perceived importance of chemistry. Kubiatko et al. (2017) reported that Czech students' attitudes towards chemistry declined in the final two years of high school. Similarly, Montes et al. (2018) found a decrease in Chilean students' attitudes as grade level increased, attributing this to more complex curriculum, greater abstraction, and the use of specific scientific language.

At the university level, Canpolat et al. (2019) found that Turkish students' attitudes varied by year, with first-year students showing more positive attitudes. They attributed this to superficial learning and exam-focused study habits in later years. In contrast, İçöz (2012) found no statistically significant differences in Turkish high school students' attitudes towards chemistry across grade levels.

Most studies indicate a decline in students' attitudes towards chemistry as grade level increases, though some report fluctuations or no distinct pattern. Overall, the effect of grade level remains unclear and inconsistent across studies.

Rationale and Purpose of the Research

Fostering positive attitudes towards chemistry remains a key goal for educators, parents, and policymakers (Brown et al., 2014). Educational stakeholders widely agree that promoting such attitudes is a central aim and outcome of the science curriculum (Montes et al., 2018).

Several studies stress the importance of student attitudes in chemistry education, warning that overlooking this factor would be a major shortcoming (Kahveci, 2015; Vilia & Candeias, 2020; Xu & Lewis, 2011). Attitude is widely viewed as a key affective factor influencing participation, performance, learning, achievement, and career choices, a view supported by various studies (Brandriet et al., 2011; Karataş, 2020; Xu et al., 2013). However, research over the past 40 years across countries has produced mixed and sometimes contradictory findings regarding the influence of variables like gender and grade level, leaving the factors shaping these attitudes uncertain.

Affective factors such as attitude, interest, motivation, and self-efficacy are vital in chemistry education for their impact on learning and achievement (Vilia & Candeias, 2020). Regular assessment of these factors helps track attitude development (Cheung, 2009b), monitor changes over time, and guide improvements in teaching and learning (Nennig et al., 2020). As Osborne et al. (2003) noted, understanding students' attitudes remains a research priority for educators and curriculum designers.

Despite widespread acknowledgement of the importance of such assessments, studies explicitly examining the relationship between students' attitudes and contextual variables remain limited both globally (Brandriet et al., 2011; Kousa et al., 2018) and within Turkey (Can & Boz, 2012; Kahveci, 2015; Karataş, 2020; Oğuz, 2020; Sezgin Saf, 2011), where this study is situated.

In this study, high school students' attitudes towards chemistry were investigated in relation to various factors. Additionally, the study explored the interrelationships among these variables, conceptualized by the authors as Gender-Achievement-Grade level (GAG) effect. The research was guided by the following questions:

1. What is the attitude level of high school students towards chemistry?
2. Is there a relationship between high school students' attitudes towards chemistry and their academic achievement?

3. Is there a relationship between high school students' attitudes towards chemistry and gender?
4. Is there a relationship between high school students' attitudes towards chemistry and grade level (age)?

METHOD

This section includes information about the research permission (ethical principles), research model, sample, data collection tool, data collection process, and data analysis.

Research Model

This study was conducted as survey research from quantitative research methods. Survey models are research approaches that aim to describe a past or current situation as it is. The event, individual, or object that is the subject of the research is tried to be defined within its own conditions and as it is. It does not make any effort to change or affect them in any way. Survey models are survey arrangements made on the entire universe or a group, sample or sample to be taken from it to reach a general judgment about the universe in a universe consisting of many elements (Karasar, 2008). In this research, the opinions of the individuals forming the sample on the subject were determined and the data was summarized and interpreted with statistical analyses.

Obtaining Research Permissions

The ethical principles determined by the American Psychological Association (2017) were followed in the conduct of the research. Before starting the research, the following procedures were carried out in order: preparation of the research application form, sending the research application form to the ethics committee and obtaining the research permission by the Ethics Committee of Science and Engineering Sciences at Balıkesir University, obtaining permission from the National Education Directorate of the province where the research will be conducted, voluntary participation approval or parental approval.

Sample

The sample of the research consists of a total of 495 high school students (15-18 years old) studying in the 9th, 10th, 11th, and 12th grades of five different state schools located in the city centre of Balıkesir. General information about the research sample is given in Table 1.

Table 1*Distribution of the sample by high school, grade level, and gender*

Schools	9th grade		10th grade		11th grade		12th grade		Total (n)
	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	
High school 1	13	16	18	10	18	6	4	17	102
High school 2	12	15	18	12	17	13	8	10	105
High school 3	14	12	14	14	10	8	5	14	91
High school 4	18	11	18	11	10	7	10	8	93
High school 5	15	13	21	7	12	14	11	11	104
Total (n)	139		143		115		98		495

The selection of the five high schools and students constituting the sample was carried out by random sampling method. The randomly selected students were also asked to volunteer. The reason why the number of students, as well as the number of girls and boys, differ based on school and grade level is due to the sampling method and the principle of volunteering.

Data Collection Tool

Attitude scale towards chemistry

The Attitude Scale Towards Chemistry (ASTC), developed by Geban et al. (1994), was employed to assess students' attitudes towards chemistry. Previous studies reported a Cronbach's alpha reliability coefficient of 0.83 for the scale (Azizoğlu, 2004). In this study, the reliability coefficient was recalculated as 0.92, indicating high internal consistency (Shadish et al., 2002).

Likert scale is perhaps one of the easiest and most direct data collection tools used to measure attitudes. Therefore, ASTC consists of 15 items on a 5-point Likert type that measure students' attitudes towards chemistry. Each scale item includes levels of agreement that students can express their opinions as "fully agree", "agree", "undecided", "disagree" and "fully disagree". Some representative items from the Attitude Scale Towards Chemistry (ASTC) include statements such as: "Chemistry is a field that I like very much" (Item 1), "Chemistry does not have a very important place in daily life" (Item 3), and "I would like to have more class hours allocated to chemistry courses" (Item 8).

As reflected in these examples, the ASTC comprises both positively and negatively worded items. Positive items were scored from 1 (fully disagree) to 5 (fully agree), while negative items were reverse-scored to ensure that higher scores reflected more positive attitudes. Therefore, the minimum possible total score on the scale was 15, while the maximum possible total score was 75. To interpret these scores, students' total attitude scores were classified into attitude levels as follows:

- 15–30: Negative attitude
- 31–45: Neutral attitude
- 46–60: Positive attitude
- 61–75: Highly positive attitude

These classifications allowed for the determination of each student's general attitude level towards chemistry based on their total ASTC score.

The affective, behavioural, and cognitive components of attitude identified by researchers (Rosenberg & Hovland, 1960) were not measured separately in this study. Although the scale encompasses items reflecting affective, cognitive, and psychomotor components, the analyses were performed without distinguishing among these dimensions, based on the rationale that reporting overall attitudes would provide a more comprehensive representation of the sample.

Chemistry academic achievement

Students' final chemistry grade averages were obtained through chemistry teachers in five participating high schools. These final grades reflect the combination of semester exam results, classroom performance, and end-of-year evaluations. To address the second research question, which examines the relationship between attitude and academic achievement, students' grades were classified based on the Ministry of National Education's grading scale:

- Fail: 0-49.99 score range (*low academic achievement*)
- Pass: 50-59.99 score range (*low academic achievement*)
- Moderate: 60-69.99 score range (*medium academic achievement*)
- Good: 70-84.99 score range (*high academic achievement*)
- Very good: 85-100 score range (*high academic achievement*)

Data Collection Process

After obtaining the necessary permissions in accordance with ethical principles, the ASTC as a data collection tool was administered to the students who constituted the sample in

the 2023-2024 academic year under the supervision of the class teacher and one of the researchers in a classroom environment. The students answered the items on the scale in 20-25 minutes. The collection of data from five high schools took 1 month.

Data Analysis

Students' responses to the attitude scale were coded and entered into SPSS 24.0 for analysis. Prior to selecting statistical procedures, the Shapiro-Wilk test was used to assess data normality, as it is considered highly sensitive and effective for various distribution shapes and sample sizes.

The attitude scores' normality result was $W(495)=0.979$, $p<0.001$, and the chemistry achievement scores' result was $W(495)=0.906$, $p<0.001$, indicating non-normal distributions for both variables. Consequently, non-parametric tests were used, including Spearman correlation analysis, the Kruskal-Wallis test, and the Mann-Whitney U test, to answer the research questions.

FINDINGS

The findings obtained as a result of the statistical analyses are presented under subheadings to answer the research questions in order.

Attitude Level

To answer the first research question, "*What is the attitude level of high school students towards chemistry?*", descriptive statistical analyses were conducted. The findings obtained as a result of these analyses are given in Figure 2.

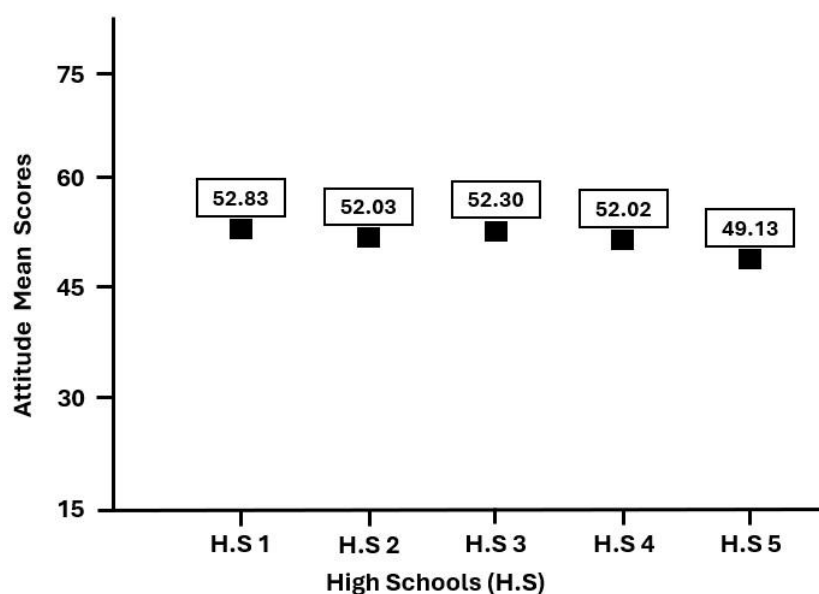


Figure 2

Mean scores of students' attitudes towards chemistry by school

When the findings were examined by the school, it was found that the mean scores of students' attitudes towards chemistry were very close to each other. The total mean score of the sample's attitude towards chemistry was calculated as 51.63.

The findings regarding the students' attitude levels towards chemistry are given in Figure 3.

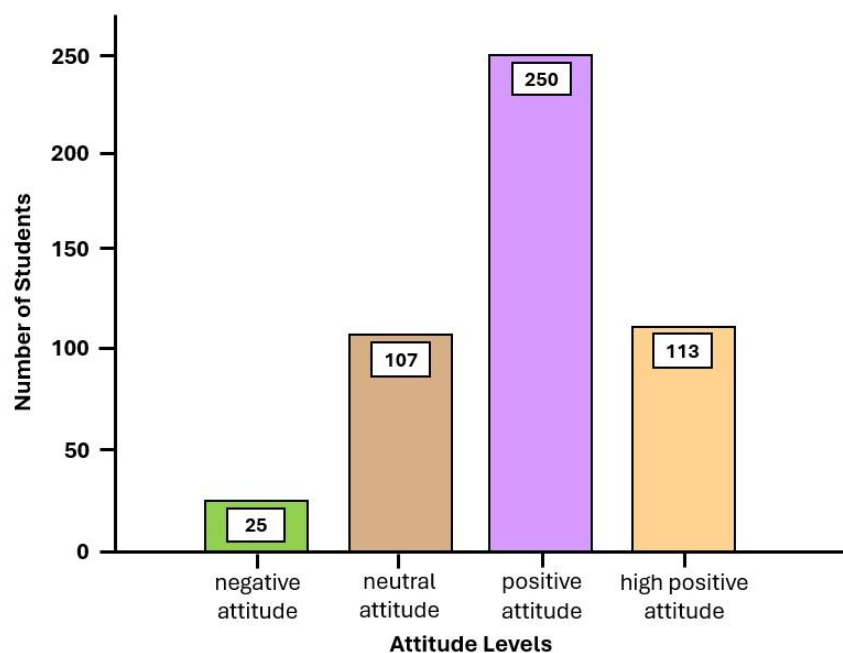


Figure 3

Attitude levels of students towards chemistry

It was determined that 5.1% (25 students) of the students constituting the sample had a negative attitude towards chemistry, 21.6% (107 students) had a neutral attitude, 50.5% (250 students) had a positive attitude and 22.8% (113 students) had a high positive attitude. This finding showed that the vast majority of students (73.3%) had a positive (positive and high positive) attitude towards chemistry.

Relationship Between Attitude and Academic Achievement

To answer the second research question, "Is there a relationship between high school students' attitudes towards chemistry and their academic achievement?", Spearman correlation analysis was conducted. As a result of this analysis, it was revealed that there was a statistically significant relationship between students' chemistry academic achievement scores and their attitude towards chemistry scores ($r=0.318$, $p<.001$).

The Kruskal-Wallis test revealed a statistically significant difference in the mean ranks of attitude scores across the different achievement levels ($\chi^2(4)=58.948$, $p<0.001$). The

proportion of variance in attitude scores explained by achievement level was 0.12 (η^2), denoting a moderate association between chemistry academic achievement and students' attitudes towards chemistry.

Table 2 presents the number of students (N), mean attitude scores, and mean rank values for attitudes towards chemistry, organized by students' chemistry achievement levels. Both the mean attitude scores and the mean rank values exhibit a progressive increase corresponding with higher achievement levels, indicating a positive correlation between chemistry academic achievement and students' attitudes towards chemistry.

Table 2

Attitude mean scores and mean ranks across chemistry achievement levels

Chemistry Achievement	N	Attitude Mean Score	Attitude Mean Rank
Fail	53	44.30	153.34
Pass	32	45.38	180.50
Moderate	55	48.49	208.35
Good	83	49.41	226.20
Very Good	272	55.11	289.06

These findings indicate that students with higher levels of achievement in chemistry generally exhibit more positive attitudes towards the subject. Specifically, those who failed demonstrated the lowest mean attitude score (44.30) and mean rank (153.34), whereas students categorized as having very good achievement displayed the highest scores (mean attitude score=55.11; mean rank=289.06).

Relationship Between Attitude and Gender

To address the third research question, "Is there a relationship between high school students' attitudes towards chemistry and gender?", a Mann-Whitney U test was performed. The result indicated a statistically significant difference between the groups ($z=-1.994$, $p=.046$). Female students demonstrated a higher average rank (259.89) compared to male students (234.19).

Figure 4 presents the findings regarding the relationship between students' attitudes and gender across different schools.

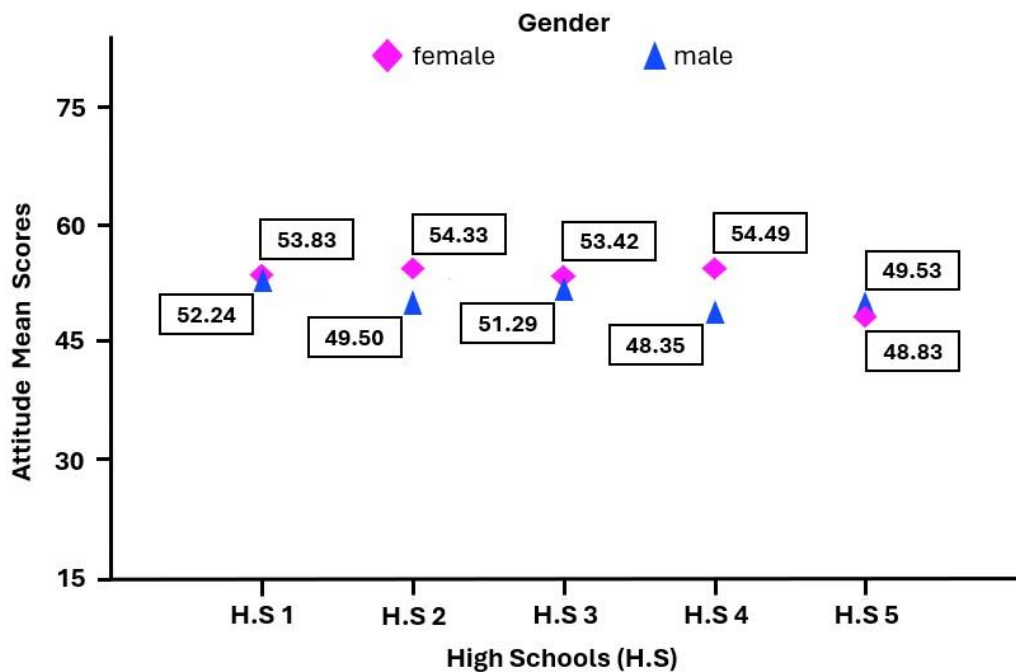


Figure 4

Mean scores of male and female students' attitude towards chemistry by school

As seen in Figure 4, it was determined that the attitude mean scores of male and female students were different from each other by school. It was found that female students ($\bar{X}=52.80$) had higher attitude mean scores towards chemistry than male students ($\bar{X}=50.28$) in all schools constituting the sample except for one high school (high school 5).

Figure 5 includes the findings regarding the relationship between attitude and gender by class level.

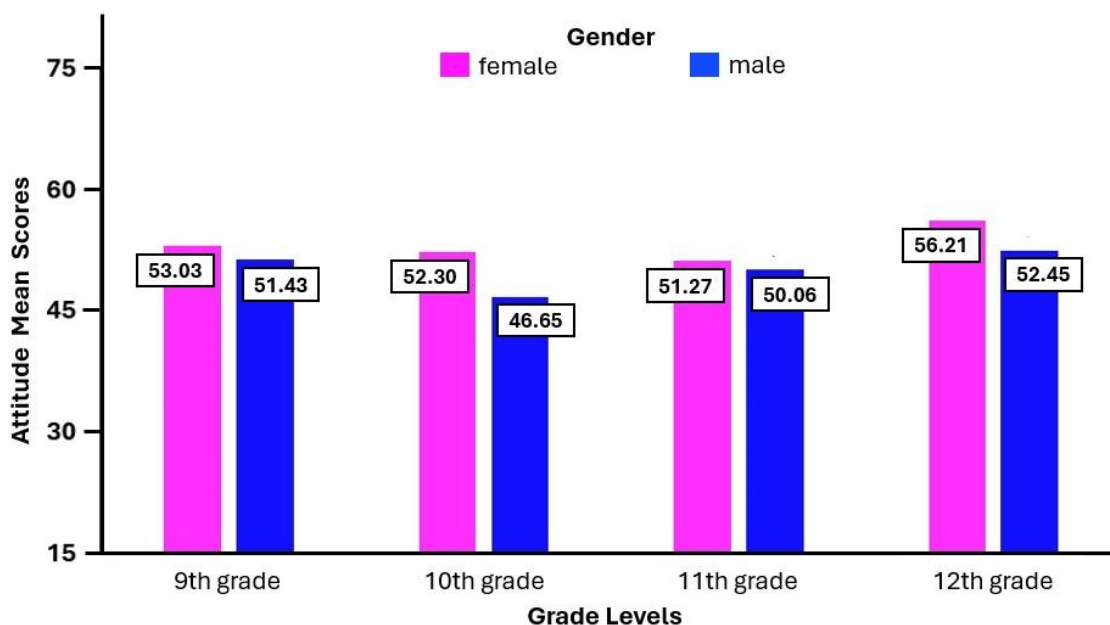


Figure 5

Mean scores of male and female students' attitude towards chemistry based on grade level

As seen in Figure 5, the attitude score means of male and female students were different from each other based on grade level. It was revealed that female students had higher mean scores regarding their attitudes towards chemistry than male students in all grade levels constituting the sample.

Relationship Between Attitude and Grade Level (Age)

In order to answer the fourth research question, "Is there a relationship between high school students' attitudes towards chemistry and grade level (age)?" Kruskal-Wallis test was conducted.

The findings obtained from the test revealed that the mean rank values of students' attitude scores towards chemistry varied across grade levels. Specifically, 9th-grade students (N=139) demonstrated a mean rank of 258.36, followed by 10th-grade students (N=143) with a mean rank of 225.81, 11th-grade students (N=115) with a mean rank of 236.65, and 12th-grade students (N=98) who exhibited the highest mean rank of 279.00. These results indicate that the mean rank values did not follow a consistent upward trend with increasing grade level; instead, fluctuations were observed across grades. Nevertheless, the Kruskal-Wallis test revealed a statistically significant difference in students' attitude scores towards chemistry across grade levels ($\chi^2(3)=9.503$, $p=.023$). The proportion of variability in the ranked dependent variable (attitude) explained by grade level was 0.02, indicating a weak association between

grade level and students' attitudes. Figure 6 presents additional findings concerning the relationship between attitude and grade level (age).

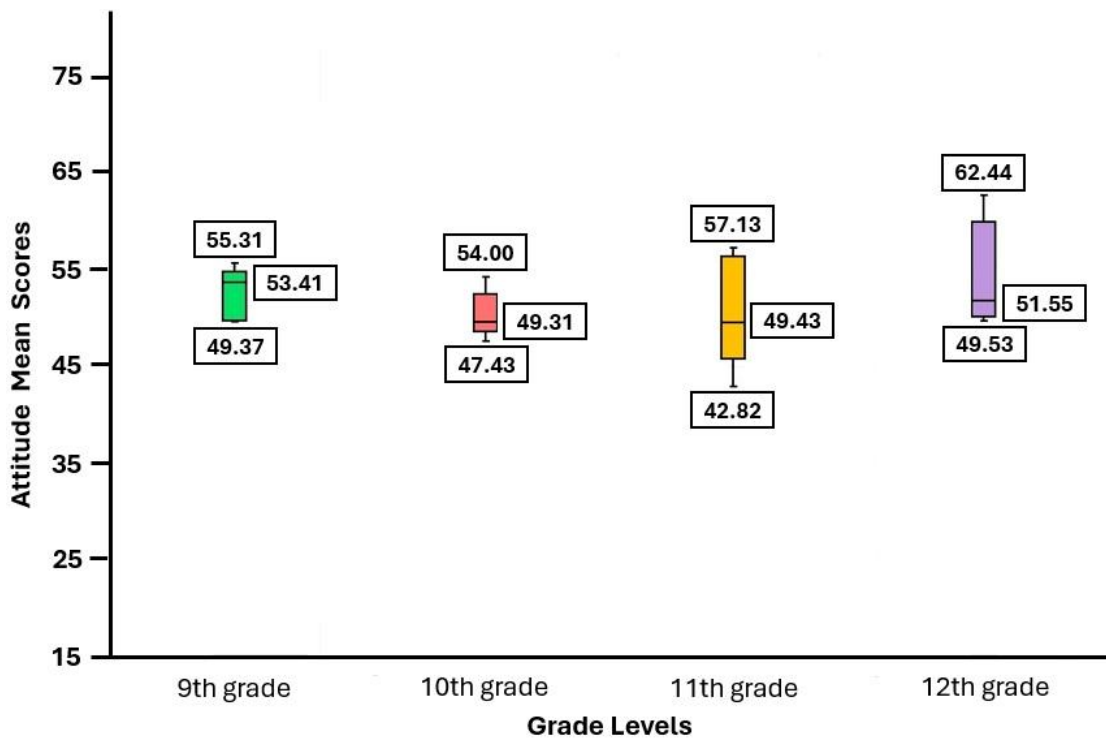


Figure 6

Mean scores of students' attitude towards chemistry by grade level

As illustrated in Figure 6, differences were observed in the mean attitude scores of students towards chemistry across grade levels. The mean attitude scores did not increase consistently with grade level; rather, they fluctuated. Specifically, the overall mean attitude scores were calculated as $\bar{X}=52.26$ for 9th grade, $\bar{X}=50.12$ for 10th grade, $\bar{X}=50.63$ for 11th grade, and $\bar{X}=54.18$ for 12th grade, respectively. These results indicate that students in the 9th and 12th grades exhibited higher mean attitude scores towards chemistry compared to their peers in the 10th and 11th grades within the sample.

Summary of the Findings

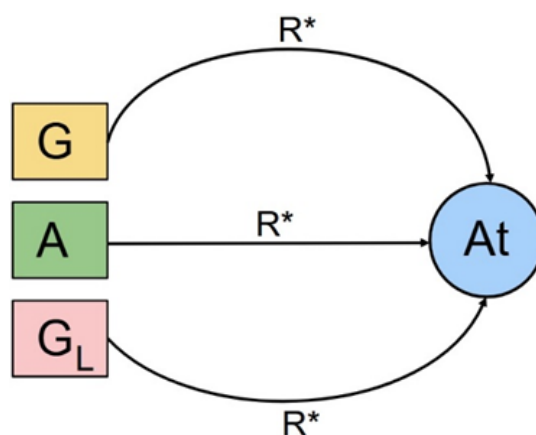
The findings from the statistical analyses are summarized in Table 3, which illustrates the effects of each variable on attitudes towards chemistry using symbolic representations.

Table 3

Summary of findings represented by symbols

Dependent variable	Relationship (R)	Independent variable	Findings
Gender (G)	significant (*)	Attitude (At)	Female _{At} > Male _{At}
Achievement (A)	significant (*)	Attitude (At)	A ↗ At ↗ (or reverse)
Grade Level (G _L)	significant (*)	Attitude (At)	12 _{At} > 9 _{At} > 11 _{At} > 10 _{At}

Figure 7 presents a graphical model illustrating the effects of each variable on attitude in an organized manner. The effect summarized in this model is referred to by the authors as the GAG effect. It is seen that all three variables (gender, achievement and grade level) significantly affect the attitude towards chemistry.

**Figure 7**

Modelling the GAG effect

DISCUSSION

In this study, the attitudes of Turkish high school students towards chemistry were examined in terms of several variables such as gender, grade level, and academic achievement. Descriptive statistical analysis performed in line with the first research question revealed that the majority of students held positive attitudes towards chemistry. This result aligns with the goals of the 2018 chemistry curriculum, which emphasizes both the relevance of chemistry to daily life and its societal contributions. The curriculum

aims to help students connect emotionally with scientists, see chemistry's practical benefits, recognize chemistry related career opportunities, and understand chemistry's role in sustaining life. These objectives likely contribute to students' generally positive perceptions, as they foster both cognitive and affective engagement with the subject.

Supporting this conclusion, previous research highlights similar reasons for positive attitudes. Students often report liking chemistry due to its tangible and observable nature, enjoy participating in practical activities such as experiments, and perceive chemistry as important for understanding the world and pursuing scientific careers (Lyons & Quinn, 2010; Osborne & Collins, 2001; Salta & Tzougraki, 2004).

Although the majority of students showed positive attitudes, a minority exhibited negative views. Literature identifies several factors that may explain such attitudes, including lack of interest, fear or anxiety related to chemistry, difficulty with abstract or memorization-heavy topics (e.g., periodic table), limited laboratory experience, and perceptions that chemistry is irrelevant to daily life or future careers (Cheung, 2009b). Furthermore, teacher-centered instruction and curriculum content that lacks real-life connections can discourage engagement. While the study sample contained few students with negative attitudes, these factors may apply to them. Recognizing these challenges is important for educators aiming to improve chemistry education by making it more inclusive and accessible.

The international literature is still blurry due to conflicting results regarding the attitudes of students from different countries towards chemistry; however, this study showed that Turkish high school students have mostly positive attitudes towards chemistry.

In line with the second research question, the Spearman correlation analysis found that there was a statistically significant relationship between students' academic achievement scores in chemistry and their attitude scores towards chemistry. The Kruskal-Wallis test further confirmed that this significant relationship was positive, indicating that students with favorable attitudes tended to achieve higher academically. This finding corroborates earlier studies showing that positive affective orientations towards chemistry enhance learning outcomes and academic achievement in chemistry (Montes et al., 2018; Oğuz, 2020). This mutual connection indicates that fostering positive attitudes may play a crucial role in improving student achievement in chemistry.

In line with the third research question, the study revealed a statistically significant difference in attitudes based on gender, with female students exhibiting more positive attitudes than male students. This was consistent across most schools and grade levels. This finding contrasts with some traditional stereotypes that associate science and chemistry with males (Salta & Tzougraki, 2004).

Possible explanations for the more positive attitudes among female students include their greater interest and enjoyment in chemistry, stronger emotional connections with scientists, better recognition of chemistry's relevance, and more favorable experiences in chemistry classes (Çalık et al., 2015; Heng & Karpudewan, 2015). Female students' more positive attitudes likely reflect the Turkish Ministry of National Education's efforts to promote gender equity and its integration of gender-inclusive elements into the revised chemistry curriculum. The present study adds significant empirical evidence concerning Turkish students, emphasizing the need to challenge stereotypes and support greater female participation in chemistry education.

Analysis of variance via the Kruskal-Wallis test conducted in line with the fourth research question, showed a statistically significant relationship between students' grade levels and their attitudes towards chemistry. However, this relationship did not follow a simple linear pattern. Instead, attitudes fluctuated across grades: 12th graders showed the highest average attitude scores, followed by 9th graders, with 11th and 10th graders scoring lower.

The literature attributes grade-level differences in students' attitudes towards chemistry to several factors, such as superficial learning, rote memorization, exam-oriented instruction, increasing complexity and abstraction in the curriculum, the use of technical language, perceived lack of relevance of laboratory work to daily life, dislike of cookbook-style experiments, and students' perception that chemistry is not essential for their preferred university programs—particularly in the final year due to exam pressure (Cheung, 2009a; Montes et al., 2018). The explanations proposed in the present study align with several of these factors.

Several studies have found that grade level significantly affects students' attitudes towards chemistry (Heng & Karpudewan, 2015; Oğuz, 2020; Ratamun & Osman, 2017); however, this effect does not consistently indicate an increase with grade progression. Instead, research has reported various patterns, including a general decline in attitudes over time (Karataş, 2020; Montes et al., 2018), a decrease specifically in the final two years of high school (Kubiatko et al., 2017), and non-linear fluctuations (e.g., Grade 9 > Grade 11 > Grade 10) (Canpolat et al., 2019). These findings suggest that curriculum developers and educators should pay close attention to maintaining student motivation and positive engagement throughout all high school years.

Overall, the findings indicate that Turkish high school chemistry education and the revised curriculum support generally positive attitudes towards chemistry, especially among female students, and that positive attitudes are linked to higher academic achievement. However, the observed fluctuations in attitudes by grade level highlight areas for potential improvement, such as curriculum design, instructional methods, and

student support systems, which include academic guidance, emotional and psychological counseling, and programs that foster student engagement and motivation.

This study also underscores the critical role of attitude in chemistry learning, confirming that affective factors are intertwined with cognitive outcomes. Attitudes influence not only knowledge acquisition but also skill development and career choices in science fields. Consequently, attitude research remains a vital area in chemistry education, requiring ongoing investigation to inform effective teaching practices.

Given the mixed and sometimes contradictory findings in international literature, the present study provides valuable insight into the Turkish context, helping to clarify some ambiguities regarding students' attitudes towards chemistry. Educators and policymakers can use these results to tailor interventions that foster positive attitudes, reduce barriers to engagement, and promote gender equity in science education.

In summary, positive attitudes towards chemistry are achievable through updated, relevant curricula and student-centered instructional strategies. Future research should continue to explore the complex dynamics of attitudes in diverse student populations to support inclusive and effective chemistry education worldwide.

Despite its significance, the international literature on attitudes remains unclear, which creates difficulties in planning the effective classroom practices. The findings of this study contribute to reducing this ambiguity by showing that Turkish students generally hold positive attitudes towards chemistry. Moreover, the study highlights the need to consider not only the empirical results but also the contextual factors influencing attitudes in chemistry education.

Accordingly, a number of suggestions are presented below to guide educators/teachers, curriculum developers, and chemistry education researchers.

SUGGESTIONS

This study utilized a Likert-type attitude scale to collect quantitative data, enabling analysis across a broad sample and various variables, which supports the generalizability of the findings. However, this method naturally limits data to statistical analysis. Future research on students' attitudes towards chemistry would benefit from incorporating qualitative approaches, such as interviews or open-ended surveys, to provide richer, in-depth insights through detailed content analysis.

The finding that female students demonstrate more positive attitudes towards chemistry—an uncommon result in the international literature—deserves further

investigation. Additional studies are needed to better understand the factors contributing to this gender difference and to enrich the discourse in science education research.

This study discussed students' generally positive attitudes in relation to the updated 2018 Turkish chemistry curriculum. Further research should explore the connection between curriculum objectives and students' attitudes to better understand how curricular design influences affective outcomes.

Where students' attitudes towards chemistry are negative, curriculum revision should be a primary consideration. Curriculum developers should explicitly include affective goals, emphasizing attitudes alongside cognitive and psychomotor domains.

Although teachers often prioritize students' academic achievement in chemistry, they tend to overlook the development of positive attitudes—one of the fundamental goals of chemistry education. To foster such attitudes, teachers should incorporate engaging and interest-driven practices into their instruction, such as enjoyable hands-on laboratory experiments. Sustained exposure to meaningful and enjoyable learning experiences can lead to a more positive outlook on chemistry over time. Research supports the effectiveness of various innovative methods in promoting positive attitudes, including flipped learning (Mooring et al., 2016), technology-supported instruction (Su, 2008), inquiry-based laboratory activities (Sesen & Tarhan, 2013), and process-oriented guided inquiry learning (Vishnumolakala et al., 2017). Such evidence should motivate teachers to adopt alternative instructional approaches, especially considering that students' attitudes may shape future career choices in chemistry.

Finally, future research examining the effects of gender, achievement, and grade level on attitudes might consider coining the term "GAG effect" to describe the combined influence of these significant variables, as identified in this study.

Conflict of Interest Declaration

The author has not declared a potential conflict of interest during the research, authorship, and publishing of this article.

Ethical Committee Decision / Permission

For this research, an ethical permission was granted by Balıkesir University Science and Engineering Sciences Ethics Committee.

GAG Etkisi: Lise Öğrencilerinin Kimyaya Yönelik Tutumlarının Modellenmesi

Bülent PEKDAĞ¹, Nursen AZİZOĞLU²

¹ Balıkesir Üniversitesi, Necatibey Eğitim Fakültesi, Balıkesir, pekdag@balikesir.edu.tr, <https://orcid.org/0000-0003-0611-0617>

² Balıkesir Üniversitesi, Necatibey Eğitim Fakültesi, Balıkesir, nursen@balikesir.edu.tr, <https://orcid.org/0000-0003-0562-9126>

Gönderme Tarihi: 16.09.2025

Kabul Tarihi: 23.09.2025

Doi: <https://doi.org/10.37995/jotcsc>.

Özet: Bu çalışmada lise öğrencilerinin kimya dersine yönelik tutumları; akademik başarı, cinsiyet ve sınıf düzeyi değişkenleri açısından incelenmiştir. Araştırma, Balıkesir ilinde bulunan beş farklı okulun 9, 10, 11 ve 12. sınıflarında öğrenim gören toplam 495 lise öğrencisi ile gerçekleştirilmiştir. Veri toplama aracı olarak "Kimya Dersine Yönelik Tutum Ölçeği" kullanılmış ve analizlerde parametrik olmayan istatistiksel yöntemler uygulanmıştır. Analiz sonuçlarına göre örneklemdaki öğrencilerin büyük çoğunluğunun kimya dersine yönelik olumlu tutumlara sahip olduğu ve kimya başarısı ile tutum arasında istatistiksel olarak anlamlı ve pozitif bir ilişki bulunduğu ortaya konmuştur. Ayrıca cinsiyet ve sınıf düzeyi değişkenlerine göre tutumlarda istatistiksel olarak anlamlı farklılıklar tespit edilmiştir. Bu sonuçlar, GAG etkisi (cinsiyet, başarı ve sınıf düzeyi) şeklinde modellenmiştir. Tartışma bölümü, 2018 Kimya Dersi Öğretim Programı ve uluslararası literatür temel alınarak yapılmıştır. Buna ek olarak araştırmacılar, öğretmenler ve program geliştiriciler için çeşitli önerilerde bulunulmuştur.

Anahtar kelimeler: GAG etkisi, tutum, akademik başarı, cinsiyet, sınıf düzeyi

Sorumlu yazar: Bülent PEKDAĞ, Matematik ve Fen Bilimleri Eğitimi Bölümü, Kimya Eğitimi Anabilim Dalı.

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