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Factors Affecting Secondary Schools Students' Attitudes toward Learning Chemistry: A Review of Literature

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Abstract

Science education is facing a challenge of students who are losing interest in learning science subjects including chemistry. This research provides a review of literature that emphasizes on the factors affecting secondary school students' attitudes toward chemistry. Thirty-six studies were selected in Google scholar and ERIC database in the time frame from 1977 to 2019. Gender, instructional methods, and grade level were found to be the most common factors positively affecting students' attitudes toward chemistry. However, students' interest, classroom environment, the relevance of curriculum, teachers' behavior, perceived difficulty and self-directed effort in the science subjects were also studied to check if there is any relation to the attitude of students while learning chemistry. The findings indicated that these factors have to be controlled to enrich positive attitudes toward chemistry among secondary students and to improve their performance in chemistry.

Keywords: Chemistry lesson, review of literature, secondary school, students' attitudes

INTRODUCTION

Chemistry is one of the science subjects that play a significant role in society. It prepares students for the real world of work through carrier opportunities such as chemical engineering, medicine, pharmacy, food science, and environmental studies (Mahdi, 2014). These provide job opportunities in numerous sectors of the economy, namely in petroleum industries, Metallurgy, ceramics, glass, plastics, cement, pharmaceuticals, food, and drinks, fertilizers, transportation, educational industries, etc.

Over the years, several studies investigated the learning achievement in chemistry at senior secondary school levels. The findings from these studies displayed the low performance of students in some essential topics, particularly the understanding of the concepts such as the writing of chemical formulae and equations and undertaking calculations from them, concepts of equilibrium of chemical reaction, and mole concepts, among others (Achor & Ukwuru, 2014; George, 2000; Lati, Supasorn, & Promarak, 2012; Supasorn & Waengchin, 2014). The chemistry was taken as an intricate and complicated subject leading the students to develop a misconception in some concepts such as electrolysis, redox reaction, acid and bases, state of matter, and organic compounds (Chiu, 2007; Johnstone, 2006). However, chemistry is of great importance to recognize the problematic areas and some misconceptions that students may encounter within chemistry concepts and propose the strategies to be adopted to address them.

Some authors revealed that the low performance in chemistry is attributed to the negative attitude towards learning and teaching chemistry and ineffective instructional techniques and teaching aids (Cheung, 2009b; Khan & Ali, 2012; Morabe, 2004). The latter was supported by Cheung (2009a), who conducted the study in Hong Kong, and the students interviewed claimed that they do not like chemistry due to the traditional teaching methods based on chalk and talk commonly used by the teachers while solving simple problems on the boards. They mentioned that their teachers prepare them only for public examination, where they are provided materials to memorize everything. Only a few

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Contribution to the literature

- This study reveals a lack of studies that specifically investigated all the factors affecting secondary school students' attitudes toward chemistry learning.
- This study demonstrates that gender, instructional methods, especially chemistry laboratory experimentation and grade levels, are the most common factors contributing to attitudes toward chemistry.
- This study gives teachers insight into specific factors to be considered while planning their lessons to improve their teaching strategies and boost quality chemistry education.

chances are given to them to conduct experiments in the laboratory.

Since most teachers rely on rote-learning in chemistry classrooms, students get bored and start developing a negative attitude towards the subject. This is supported by Morabe (2004), who pointed out some factors contributing to students' negative attitudes toward science, namely teachers' inability to conduct practical activities of good quality, inadequate knowledge of the scientific concept, and the perceived difficulty of science, chemistry inclusive. Therefore, students need more assistance to develop good attitudes in chemistry topics.

Different studies conducted indicated that the attitudes of students toward science negatively change during secondary school (Cheung, 2009b; Hofstein, Ben-Zvi, Samuel, & Tamir, 1977; Hofstein & Mamlok-Naaman, 2011; Kubiatko, Balatova, Fancovicova, & Prokop, 2017; Salta & Tzougraki, 2004). However, there are limited studies that have identified some of the factors that may contribute to the attitudes of secondary school students toward chemistry learning (Inye, 2011; Liaghatdar, Soltani, & Abedi, 2011; Najdi, 2018; Osborne, Simon, & Collins, 2003; Weinburgh, 1995). It is essential to identify all factors that may predict the students' attitudes toward chemistry among secondary schools. Therefore, this study's main aim was to investigate all the factors that could impact the change in students' attitudes toward chemistry learning. The outcomes of this study will provide insight to teachers, parents, and school administrators.

Purpose

The purpose of this study is to investigate the common factors affecting students' attitudes toward chemistry.

The following research questions guided the study:

1. What are the factors affecting secondary students' attitudes toward chemistry learning?
2. To which level of statistical significance, these factors affect students' attitudes?

REVIEW OF LITERATURE

This review highlights the definitions given to attitude towards science. It also discusses the importance of developing positive attitudes toward chemistry. Lastly, it indicates some studies that have surveyed students' attitudes toward chemistry.

Defining Attitude toward Science

The word "attitude" has been defined by many scientists around the world. They all come with the same conclusion that attitudes toward science are viewed as a combination of individual values, feelings, and beliefs toward science (Hacieminoglu, 2016; Montes, Ferreira, & Rodríguez, 2018; Morabe, 2004; Salta & Tzougraki, 2004). Similarly, attitudes are the act of feeling or thinking either positively or negatively toward something in the environment (George, 2000). Attitudes are feelings of "like or dislike of an object, person, or an event that characterize a human being (Heng & Karpudewan, 2015; Hofstein et al., 1977). Moreover, attitudes are considered outcomes that can be acquired during the learning process (George, 2000; Oh & Yager, 2004). Therefore, students' attitudes change in their learning process either directly or indirectly through observation, experiences, and the learning environment. Hence the change in attitude is mostly influenced by teachers, parents, peers' characteristics, and classroom environment (George, 2000; Talton & Simpson, 1987).

Importance of Developing Positive Attitudes toward Chemistry

The development of students' attitudes toward chemistry is one of the most critical components of science education as students' attitudes significantly impact learning (Lovelace & Brickman, 2013). According to Oh and Yager (2004), lifelong learning and interest in science are influenced by positive feelings toward science commitment. Cheung (2009a), Khan and Ali (2012), Najdi (2018), and Salta and Tzougraki (2004) have investigated the importance of developing a positive attitude towards learning of chemistry among secondary schools' students, and their findings showed that the attitude is directly linked to the academic achievement and the attitude is a predictor of behavior.

It has also been reported that students with a positive attitude are trying to excel in the subject being taught compared to those with a negative attitude (Adesoji, 2008; Brandriet, Xu, Bretz, & Lewis, 2011; Heng & Karpudewan, 2015; Lerman, 2014). This is supported by

the works done by Mushinzimana et al. (2016); Ngila & Makewa (2014); Weinburgh (1995), who reveals that there is a positive correlation between students' achievement and their attitude towards science subjects. However, Morabe (2004) states that an unfavorable attitude to a particular subject causes difficulty learning as there is a lack of interest and confidence in the subject. According to Özden (2008), factors that may interrupt the proper teaching and learning environment should be considered while preparing the lessons. The contents should also be well designed to inculcate the desirable attitude and values among the students. These help shape their attitude, behaviors, and motivation, influencing their cognitive skills and active participation in the teaching and learning process.

Studies on Students' Attitudes toward Chemistry

One of the impacts of Science Education is to help different individuals to develop a positive attitude towards science (Hacieminoglu, 2016). However, it was indicated that students' enrollment in science subjects at the secondary level is declining (Awan & Sarwar, 2011). The latter affected the rate of students pursuing science-related carriers to be relatively low. Furthermore, it was reported that students' attitudes are most favorable in biology and least positive in chemistry and physics (Awan & Sarwar, 2011; Cheung, 2009b). Students' ignorance was one reason for a decrease in their positive attitudes towards science and science-based careers (Osborne et al., 2003). Further studies and reports carried out in the U.S. and in Europe attributed these factors to the lack of relevant content and pedagogical approaches at school levels (Hofstein & Mamlok-Naaman, 2011).

Besides, some studies have investigated the attitudes of students toward chemistry learning among secondary students. For instance, research was conducted in Chile to explain secondary school students' attitudes toward chemistry (Montes et al., 2018). The results pointed out that the attitudes of Chileans students toward chemistry were neutral. They have relatively positive feelings or emotions in chemistry, but they believe that their content is tricky and challenging. Also, their attitudes seemed to decrease as they progress from lower to the higher year group. The gender difference was not appearing in this study. Furthermore, the authors found a strong relationship between chemistry achievement and attitudes.

Similarly, Salta and Tzougraki (2004) investigated secondary students' attitudes toward chemistry in terms of difficulty, interest, usefulness, and chemistry importance. Their results indicated that the attitudes of Greek students were neutral. Though they have acknowledged the importance of chemistry in their lives, they do not realize the usefulness of chemistry courses in their future lives. Their results also revealed that boys' and girls' attitudes in the level of interest, usefulness, and importance given to chemistry were identical. Meanwhile, it was not the case in a study conducted by Seba et al. (2013) in Tanzania, whose study indicated a difference between boys' and girls' attitudes toward chemistry in the level of anxiety, enjoyment, and confidence. Male students were found to have more confidence, excellent performance, and enjoyment in physics and chemistry than their girls' counterparts. As a result, boys have more positive attitudes toward chemistry and physics than girls, and they tend to participate more in chemistry and physics activities than female students.

Further research that examined secondary students' attitudes toward chemistry was carried out by Kubiatko et al. (2017) in the Republic of Czech. They focused on pupils' perception of chemistry in four dimensions (popularity and difficulty of chemistry, the relevance of chemistry, chemical aids and laboratory experiments, and future life and chemistry). Pupils have recognized the relevance of chemistry, but they did not perceive any connection between chemistry and their future life. Hence, they developed slightly positive attitudes toward chemistry. Because of the influence of gender and grade level were also the basis of this study, their effect was not significant. In lower secondary school, girls had more positive attitudes than boys, and the opposite was found in the 2nd and 3rd-grade level.

Besides, there are many studies carried out to investigate the effect of instructional methods on students' attitudes among secondary schools students (Akcay, Yager, Iskander, & Turgut, 2010; Barchok, Too, & Ngeno, 2013; Festus & Ekpete, 2012; Juntunen & Aksela, 2013; Khan & Ali, 2012; Kousa, Kavonius, & Aksela, 2018; Oh & Yager, 2004; Singh & Chibuye, 2016). Others have also indicated the influence of grade level (Akarsu & Kariper, 2013; Can & Boz, 2012; Heng & Karpudewan, 2015; Hofstein et al., 1977; Kubiatko et al., 2017; Menis, 1989), gender (Akarsu & Kariper, 2013; Akcay et al., 2010; Heng & Karpudewan, 2015; Kenar, Ali, Ali, & Demir, Halil, 2015; Kubiatko et al., 2017; Menis, 1983; Ngila & Makewa, 2014; Osborne et al., 2003; Seba et al., 2013; White & Harrison, 2012) and that of teachers' characteristics (Adegbola & Depar, 2019; Chepkorir, Cheptonui, & Chemutai, 2014; Inye, 2011; Yunus & Ali, 2012).

METHODOLOGY

This study adopted the desk review method to review the previous studies to determine the information required to respond to the proposed research questions. A desk review is also known as secondary research, where the researcher reviews the previous research findings done by other people to make them more significant. The research is done through the internet exploration over Google Scholar and ERIC database to acquire studies investigating the factors affecting students' attitudes toward chemistry

worldwide. By referring to "students' attitudes toward chemistry" as a keyword, 40 studies were explored. The search was expanded to obtain more studies that could increase the data by using "students' attitudes toward science" as a search term. Studies that do not fulfill the research inclusion criteria were removed. Here below are the inclusion criteria followed:

- The reviewed papers should be a published article conducted in the field of science.
- It should have examined the students' attitude towards chemistry in particular or science in general
- It should cover one or more factors affecting students' attitudes toward chemistry/science
- It should have been fulfilled at secondary schools' grades, and
- It had to be published in a well reputable journal, not in predatory journals.

In total, one hundred and fourteen (114) studies were explored and analyzed. Studies that do not highlight any factor that affects students toward science or chemistry were removed. Therefore, 51 studies were rejected, and studies that were carried out on university students and primary students (27) were also removed. Thirty-six (36) studies were approved to be analyzed in this review because they were comprising some of the factors that affect students toward science, and they were published between 1977 and 2019.

RESULTS

The reviewed studies revealed several factors affecting attitudes toward chemistry learning, and each factor was depicted in different studies. Table 1 shows the factors analyzed in one or more of the reviewed studies and their level of significant influence on student attitudes toward chemistry. Based on the studied factors, they were grouped according to authors. Factors such as instructions methods, teaching aids and availability of infrastructure, students' interest, classroom environment, gender, grade level, teachers' behaviors or characteristics, social, environmental factors that (include parent, peers, friends, social-economic class, and social-cultural context), perceived difficulty of science/chemistry or how science is perceived, and self- directed effort were found to affect attitudes of students toward chemistry positively. The curriculum's relevance negatively affected students' attitudes, and few studies showed no effect.

Among the eleven factors, gender was tackled in 19 studies out of 36. Thirteen clearly showed their significant main effect ($p < 0.05$ (Can, 2012; Heng & Karpudewan, 2015; Kenar et al., 2015; Kubiatko et al., 2017; Menis, 1983), a highly significant effect with $p<0.01$ (Anwer et al., 2012) and others with a very high significant main effect of $p < 0.001$ (Cheung, 2009b; Heng & Karpudewan, 2015; Hofstein et al., 1977; Salta & Tzougraki, 2004). However, six studies showed no effect of gender on the attitude of students (Akcay et al., 2010; Inye, 2011; Montes et al., 2018; Najdi, 2018; Ngila & Makewa, 2014; Sakariyau et al., 2016), ($p > 0.05$).

Instructional methods were discussed in 13 studies, twelve of them displayed the positive effect, some with a statistically significant of $p < 0.05$ (Adesoji, 2008; Akcay et al., 2010; Oh & Yager, 2004; Olakanmi, 2008), a high statistical significance of $p < 0.01$ (Freedman, 1997; Singh & Chibuye, 2016; Tuysuz, 2010) and with a very high statistical significance of $p < 0.001$ (Lin et al., 2014). The use of collaborative concept mapping teaching strategy showed no effect on secondary students' attitudes toward chemistry (Barchok et al., 2013).

Similarly, another factor the grade level was disclosed in 9 studies out of the 36, seven of them clearly showed their positive effect (some with a statistically significant effect of $p < 0.05$ (Can, 2012; Can & Boz, 2012), a high statistical significant effect with $p < 0.01$ (Cheung, 2009a; Hofstein et al., 1977), and a very high statistical significant effect with $p <0.001$ (Heng & Karpudewan, 2015; Montes et al., 2018). Two studies showed no effect of grade level on students' attitudes towards chemistry (Akarsu & Kariper, 2013; Kubiatko et al., 2017).

Table 1. Factors affecting students' attitudes toward chemistry and their level of significance

S/n	Factors	A study conducted by:	Descriptive or inferential statistics (level of statistical significance)	Effect
1	Instructional methods			
	1. Conducting a Chemistry experiment	(Yunus & Ali, 2012)	85% of students preferred the practice of chemistry experiment in learning chemistry	Yes (+)
		(Freedman, 1997)	Students treated using laboratory instruction showed a higher score and a positive attitude ($p<0.01$).	Yes (+)
	2. Use of the constructivist approach	(Oh & Yager, 2004)	The attitudes of students toward science developed more positively when the science classroom turned more constructivist ($p<0.05$)	Yes (+)
	3. Scientific fields trips	(Kousa et al., 2018)	Students attitudes toward chemistry learning positively increase when they conduct scientific fields trips	Yes (+)
	4. Use of Problem-Based-Solving Techniques (P.B.S.T.)	(Festus & Ekpete, 2012)	There was an effect of P.B.S.T. over traditional instruction (t-cal (28.9) > t- critical (1.96) at a significance level of 0.05)	Yes (+)
	5. Use of Collaborative Concept Mapping Teaching Strategy	(Barchok et al., 2013)	There was no significant difference in attitudes towards Chemistry between the students exposed to C.C.M. and those exposed to conventional teaching strategy ($p>0.05$)	No
	6. Use of the Virtual Laboratory	(Tuysuz, 2010)	There was a positive effect of virtual laboratory instruction over the traditional teaching method ($p=0.01$).	Yes (+)
	7. Use of Problem-Solving Instructional Strategy	(Adesoji, 2008)	The application of Problem-Solving Instructional Strategy showed a positive effect at 0.05 significant level ($p<0.05$)	Yes (+)
	8. Use of Science-Technology-Society (S.T.S.) approach	(Akcay et al., 2010)	There was a significant difference between students taught with the S.T.S. approach, and those taught with a textbook-oriented approach ($p<0.05$).	Yes (+)
	9. Use of Ethnochemistry Practices	(Singh & Chibuye, 2016)	There was a highly significant effect of incorporating the Ethno-chemistry practices in teaching chemistry on students' attitude towards chemistry ($p= 0.002$)	Yes (+)
	10. Use of Learning activities that combine science magic activities with the 5E instructional model	(Lin et al., 2014)	There was a very high statistically significant with p=.000 while using learning activities that combine science magic activities with the 5E instructional model	Yes (+)
	11. Use of a combination of socio-scientific issue of life-cycle thinking with inquiry-based learning approaches	(Juntunen & Aksela, 2013)	There was a positive effect of inquiry-based life-cycle on students' attitudes towards chemistry and environmental literacy.	Yes (+)
	12. Use of Web-based computer simulation	(Olakanmi, 2008)	The use of web-based computer simulation positively increased students' attitudes towards chemistry ($p<0.05$)	Yes (+)
2	Teaching aids & availability of infrastructure	(Chepkorir et al., 2014)	The presence of teaching aids and the availability of infrastructure positively affect students' attitude towards chemistry learning	Yes (+)
		(Inye, 2011)	Adequate use of laboratory, textbooks, and notebooks positively affects the attitudes of students toward chemistry ($X^2_{0.05} > X^2_c$)	Yes (+)
		(Adegbola & Depar, 2019)	The use of instructional materials influences students' attitudes towards basic science positively.	Yes (+)
3	Interest	(Yunus & Ali, 2012)	Students interest increases both the performance and attitudes towards chemistry	Yes (+)
		(Inye, 2011)	There was a significant difference between students' interest and their attitudes towards science education ($X^2_c > X^2_{0.05}$).	Yes (+)
4	Classroom environment	(Oh & Yager, 2004)	Constructivist classroom environment positively influence students' attitudes toward science learning ($p < 0.01$)	Yes (+)
		(Ngila & Makewa, 2014)	There was no significant difference in attitudes toward chemistry between borders and day scholars ($p > 0.05$).	No
		(Montes et al., 2018)	There was no significant effect of school type on students' attitudes toward chemistry ($p = 0.053$).	No
		(Anwer, Iqbal, & Harrison, 2012)	There was a significant difference between rural and urban students' attitudes toward science ($p < 0.01$). Rural students had a higher attitude towards science than urban students.	Yes (+)
		(Yildirim, 2018)	There was a meaningful difference between students exposed to out of school learning environment and those not exposed to the same environment ($p = 0.001$, $p < 0.05$).	Yes (+)
		(Talton & Simpson, 1985)	Classroom environment like climate, curriculum, physical environment variables showed a strong relationship with the attitude towards science	Yes (+)
5	Relevance of curriculum	(Yunus & Ali, 2012)	71.2% of students claimed that the chemistry syllabus is too broad, resulting in negative learning attitudes.	Yes (-)
6	Gender	(Cheung, 2009b)	There was a significant main effect for gender with $p < 0.001$).	Yes (+)
		(Can, 2012)	Gender showed a significant effect with $p < 0.05$	Yes (+)
		(Hofstein et al., 1977)	A very high significant difference exists between boys and girls ($p < 0.001$). Girls developed more positive attitudes than boys.	Yes (+)

A factor with a positive effect is represented by **Yes (+)**, that with a negative effect is represented by **Yes (-).** The factor that shows no effect is represented as **No**

Table 1 (continued). Factors affecting students' attitudes toward chemistry and their level of significance

S/n	Factors	A study conducted by:	Descriptive or inferential statistics (level of statistical significance)	Effect
6	Gender	(Kubiatko et al., 2017)	The results showed a statistical significance between girls and boys with $p < 0.05$	Yes (+)
		(Kousa et al., 2018)	Boys had more positive attitudes than girls	Yes (+)
		(Weinburgh, 1995)	A significant effect was found between boys and girls (effect sizes was .20 (S.D. =.50) for boys and .16 (S.D. = .50) for girls)	Yes (+)
		(Salta & Tzougraki, 2004)	Avery high significant difference was found with $p < 0.001$in terms of difficulty of chemistry. Boys with more positive attitudes than girls	Yes (+)
		(Menis, 1983)	A significant difference was found between boys and girls with $p < 0.05$. Boys with a more positive attitude	Yes (+)
		(Heng & Karpudewan, 2015)	Gender showed a significant result with $p < 0.005$. Girls with more positive attitudes.	Yes (+)
		(Ngila & Makewa, 2014)	There was no significant difference in attitude towards chemistry between boys and girls ($p > 0.05$). Their attitudes were the same.	No
		(Seba et al., 2013)	The attitude of boys was higher than that of girls	Yes (+)
		(Najdi, 2018)	$P = 0.156$, there was no significant difference between male and female students' attitudes toward chemistry.	No
		(Montes et al., 2018)	No significant effect of gender on attitude was found ($p = 0.57$).	No
		(Kenar et al., 2015)	A significant effect of gender on attitude was found with $p = 0.002$	Yes (+)
		(Sakariyau, Taiwo, & Ajagbe, 2016)	There was no significant difference between male and female attitudes towards science (t-calculated = 0.42< t-table value of 1.97 at 0.05 level of significance).	No
		(Anwer et al., 2012)	A significant difference in gender on attitude was found with $p < 0.01$. Girls with more positive attitudes than boys	Yes (+)
		(Liaghatdar et al., 2011)	Girls were found to have a more positive attitude	Yes (+)
		(Inye, 2011)	No significant difference in gender was found ($X^2_c < X^2_{0.05}$.	No
		(Akcay et al., 2010)	No significant difference of Science-Technology-Society (S.T.S.) on female and male students was found in terms of attitude towards science	No
7	Grade level / year group	(Heng & Karpudewan, 2015)	A high significant effect of grade level on attitude towards learning chemistry was found with $p < 0.001$	Yes (+)
		(Can, 2012)	A significant effect of grade level was found ($p < 0.05$)	Yes (+)
		(Montes et al., 2018)	Year group showed a significant effect on attitude ($p < 0.001$)	Yes (+)
		(Cheung, 2009b)	Grade level showed a significant main effect on attitude ($p < 0.005$)	Yes (+)
		(Hofstein et al., 1977)	A significant difference in grade level was found in the study of chemistry and the social-economic image ($p < 0.01$)	Yes (+)
		(Kubiatko et al., 2017)	No significant effect of grade level was found ($p = 0.34$)	No
		(Can & Boz, 2012)	A significant difference of attitudes towards chemistry across grade 9 to11was found with $p<0.05$	Yes (+)
		(Akarsu & Kariper, 2013)	No significant effect of grade levels was found	No
		(Menis, 1989)	A significant difference in grade levels toward science was found. Grade 12 was more positive than grade 11	Yes (+)
8	Teachers' behavior	(Yunus & Ali, 2012)	80% of the students agreed to possess positive attitudes when their teachers are expert in the subject and are willing to share their knowledge	Yes (+)
		(Najdi, 2018)	Students' attitude change depending on the way chemistry teachers approach the material	Yes (+)
		(Inye, 2011)	$X^2_{0.05} > X^2_c$, the attitudes of students are influenced by their teachers.	Yes (+)
		(Chepkorir et al., 2014)	60% of the students were found to be comfortable with their teachers' teaching methods; 75% agreed that their chemistry teacher provides extra support even outside the regular class hours, and hence they were likely to develop positive attitudes.	Yes (+)
		(Adegbola & Depar, 2019)	Not all the components of teachers' pedagogical competence, such as instructional material, knowledge of the subject content, teacher's motivation, communication style, and teaching style, influence students' attitude. Only the use of instructional material was found to influence students' attitudes significantly.	No
9	Social, environmental factors	(Kenar et al., 2015)	A significant difference was observed while considering the mother's educational status ($p < 0.05$). Also, a significant difference was observed according to the income level variable ($p < 0,05$)	Yes (+)
			No significant difference was observed considering the father's educational status ($p > 0.05$).	No
		(Inye, 2011)	No significant effect of parents on students' attitudes toward science was found ($X^2_c > X^2_{0.05}$.)	No
		(Akarsu & Kariper, 2013)	Parents' educational level was found to affect the attitude of students positively	Yes (+)
10	Perceived difficulty of science/chemistry	(Khan & Ali, 2012)	65% of the students revealed that they do not consider chemistry as their favorite subject due to its difficulty in nature	Yes (+)
11	Self-directed effort	(Liaghatdar et al., 2011)	Girls' self-directed effort was found to be higher than that of boys and hence developed a more positive attitude	Yes (+)

A factor with a positive effect is represented by **Yes (+)**, that with a negative effect is represented by **Yes (-).** The factor that shows no effect is represented as **No**

DISCUSSION

Gender

From the reviewed studies, the majority (19 out of 36) included gender as a factor contributing positively to the attitudes of students toward the learning of chemistry and examined gender differences in students (Can, 2012; Cheung, 2009a; Hofstein et al., 1977; Kubiatko et al., 2017; Ngila & Makewa, 2014). Unfortunately, there were no reliable results that were provided by their works. While in some studies, girls were found to develop favorable attitudes toward learning chemistry when compared to their boys' counterparts (Heng & Karpudewan, 2015; Hong & Lin, 2011; Kenar et al., 2015; Liaghatdar et al., 2011), this was not the case in some other studies that proved the positive attitudes of boys toward chemistry compared to girls in general (Anwer et al., 2012; Cheung, 2009b; Kousa et al., 2018; Menis, 1983; Salta & Tzougraki, 2004; Seba et al., 2013). Furthermore, other studies highlighted that boys' and girls' attitudes were equivalent to chemistry education (Akcay et al., 2010; Najdi, 2018; Ngila & Makewa, 2014; Sakariyau et al., 2016). Hofstein and Mamlok-Naaman (2011) found these inconsistencies in their study of high secondary students' attitudes and interest in learning chemistry.

However, it is observed that boys have developed more positive attitudes than girls toward chemistry learning. This is supported by the results of a meta-analysis of the consulted literature from 1970 to 1991 conducted by Weinburgh (1995) on gender differences in students' attitudes toward science. Girls' attitudes are probably caused by some socio-cultural context, which favors boys to study the hardiest subjects such as chemistry, regarded as a difficult subject after physics. It might also be due to the content of the curriculum being taught. Furthermore, the teacher's instructional methods could hinder girls' attitudes toward chemistry, mainly when hands-on activities do not stimulate girls to participate actively in the learning process. They will stay quiet and shy to express their knowledge, may be because the teaching method used does not meet their expectations, or it does not reflect the applicability and the importance of the subject to daily life. Thus, they get bored with the lesson being taught, thereby developing negative attitudes toward the subject. Therefore, science education could reinforce gender equity in science learning in general and chemistry to eliminate gender stereotypes in education.

Instructional Methods

Apart from the gender factor, teachers' instructional methods are also among the most studied factors affecting students' attitudes toward chemistry. Therefore, it can be presumed that the magnitude of attitudinal change may depend on the instructional approaches used during the learning process (Cheung, 2009a; Khan & Ali, 2012; Oh & Yager, 2004; Salta & Tzougraki, 2004). For instance, the chemistry laboratory experimentation was the most common and effective instruction method that promotes students' attitudes toward science (Chepkorir et al., 2014; Freedman, 1997; Najdi, 2018; Yunus & Ali, 2012). This could be explained that centered laboratory activities to practice the theory learned in the classroom enhance students' meaningful learning. Students are more likely to enjoy laboratory activities and hence improve their understanding of the concept being taught. Laboratory increases students' interest in learning chemistry as it favors hands-on learning when contrasted to other instructional methods like group discussion, demonstrations' method, and lecturing methods (Yunus & Ali, 2018).

Najdi (2018) was interested in another instructional method, which is the use of multimedia-aided teaching. The latter was the most effective instructional method that promotes elementary students' attitude towards science (Shah & Khan, 2015). Olakanmi (2008) indicated that web-based computer simulation improved students' attitudes towards learning chemistry. This creates an environment through which students can interact with one another and actively participate in the learning process instead of being passive. The role of the teacher is to assist and guide the students in the learning environment. Beneficial interactions occur among students themselves, between students and the learning materials, and between students and teachers when web-based instruction is used correctly (Olakanmi, 2008).

Grade Level

Grade level is another factor discussed by some authors; nine studies out of 36 preferred to use grade level as a factor influencing students' attitudes toward chemistry (Cheung, 2009b; Heng & Karpudewan, 2015; Hofstein et al., 1977; Kubiatko et al., 2017; Montes et al., 2018). This was supported by the work conducted by Menis on attitudes toward school Chemistry and science among upper secondary chemistry students in the United States. The results showed that grade 12 students possess more positive attitudes toward chemistry than grade 11 students (Menis, 1989). Such an increase in attitude was not found by Hofstein et al. (1977). Thus, they noticed a decline in students' attitudes toward chemistry when they progress from 11^{th} to 12^{th} grade.

This can be explained by the fact that the curriculum's content is not too wide in lower classes, and the materials to be discussed are not hardened. They are mostly related to students' everyday lives. As they progress to the upper level, materials in the curriculum increase, leading to the abstract concepts requiring a higher level of thinking. Curriculum content is, therefore, regarded as being overloaded. This results in the students' failure to make connections between the concepts studied and

their applicability in everyday life and hence do not find its relevance (Hofstein & Mamlok-Naaman, 2011). It is not far from Oh and Yager (2004), Yunus and Ali (2018) who state that the chemistry syllabus is too extensive for both the students and teachers to handle in a limited time. Although teachers have to work overtime, and students require extra time to complete the syllabus. If students are provided with plenty of scientific information, they become nervous and develop more negative attitudes.

The Relevance of the Curriculum

The curriculum's relevance is another major factor affecting students' chemistry (Cheung, 2009a; Osborne et al., 2003). Only one study mentioned the negative effect of the curriculum's relevance in this review (Yunus & Ali, 2018). This work indicated that the majority of students (71.2%) developed negative attitudes due to the chemistry syllabus, which was suggested to be too broad. This can be explained because when the materials to be discussed are too vast, and teachers only matter on completing the curriculum without guiding the students to acquire relevant skills. This is in line with the research carried out in German by Eilks and Marks (2008). The authors argue that the chemistry content in particular and science, in general, is lacking relevance to them due to the lack of relevance of teaching chemistry, and this leads to a low level of motivation and the lack of interest in science. Therefore, the subject area's relevance and attitudes are related to how students find the chemistry content from which they learn relevant concepts to their daily life and their society by developing positive attitudes towards the subject.

Social Environment

Social-environmental factors (parents, peers, friends, social-economic class, and social-cultural context) were also found to induce students' attitudes toward chemistry learning, as emphasized in three studies (Akarsu & Kariper, 2013; Inye, 2011; Kenar et al., 2015). Though Inye (2011) did not found a significant effect of parents on students' attitudes toward science, some studies (Akarsu & Kariper, 2013; Kenar et al., 2015) showed parents' role in developing attitudes of students. One of the reasons for this finding may be that each parent (either the mother or father) has ambitions and aspirations that he/she wants for his/her child's future education and occupation. Therefore, the inspiration from them, their encouragement to participate in some science activities such as science fairs and clubs, and their motivation to visit libraries and museums may foster positive attitudes toward science. A further study done by White and Harrison (2012) confirmed that parents' influence appears to be more significant than teachers or other individuals' influence.

Osborne et al. (2003) pointed out that a strong relationship between parental support and attitudes to science exists, but more emphasis is being added on the mother's support. This could be because mothers are the ones who spend most of their time with the children in most cases. They usually help them to revise and complete their homework on time. Hence, they expect the first place in class from their children because of the support provided. Kenar et al. (2015) also observed a significant difference in students' attitudes according to their parents' income level. The effect of socio-economic status on students' aspirations and attitudes is highlighted in a study by White and Harrison (2012). They suggested that students who are more interested in science are usually those from higher socio-economic backgrounds. This decreases students' interest with low-income levels to pursue science subjects and develops a negative attitude in science subjects.

Classroom Environment

The classroom environment has also been reported as a significant predictor of science (Anwer et al., 2012; Montes et al., 2018; Ngila & Makewa, 2014; Oh & Yager, 2004; Yildirim, 2018). This was revealed in six studies, with two showing no impact (Montes et al., 2018; Ngila & Makewa, 2014). However, the four remaining showed positive effects (Anwer et al., 2012; Oh & Yager, 2004; Talton & Simpson, 1987; Yildirim, 2018). According to Talton and Simpson (1987), the classroom's physical environment, the climate within the classroom, activities taking place within the science classroom, and student interactions with their classmates, teachers, and curriculum should be considered in examining individual' attitudes. Oh and Yager (2004) investigated constructivist classroom environments' effectiveness to enhance science attitudes. These findings imply that teaching and learning environments should be designed to allow students to construct knowledge from experience and gain a more positive attitude toward science.

Teacher's Behavior

Teachers' behavior and characteristics greatly influenced students' attitudes toward chemistry learning. This factor was found in five studies, one study with no effect (Adegbola & Depar, 2019), and four with positive effects (Chepkorir et al., 2014; Inye, 2011; Najdi, 2018; Yunus & Ali, 2018). It is clear that the ways through which teachers behave affect the attitudes of students. This may be attributed to the fact that the knowledgeable teachers who are experts in the subject being taught share their knowledge and expertise easily. They allow students to ask questions or give ideas and opinions on the subject and reflect them immediately (Yunus & Ali, 2018). Through the interactions, students can discuss with their teachers and peers to enhance their

understanding of chemistry, improving the level of thinking.

Teaching Aids and Availability of Infrastructure

The influence of teaching aids and the availability of infrastructure in shaping students' attitudes were also discussed in three studies (Adegbola & Depar, 2019; Chepkorir et al., 2014; Inye, 2011). They proved that the presence of teaching aids and availability of infrastructures such as laboratory equipment, computers, textbooks, notebooks, among others, positively affect the attitudes of students toward chemistry. One of the possible reasons is that the use of teaching aids helps students to make a connection between chemistry with phenomena that take place in their daily life. Failure to use adequate instructional materials and to avail textbooks to both students and teachers negatively affects students' attitudes. Furthermore, they help teachers clarify some abstract concepts in chemistry and cause a deep understanding of chemistry concepts. Priyambodo and Wulaningrum (2017) established similar results in their study, which used chemistry teaching aids based on local wisdom. The students agreed that the use of teaching aids could improve their motivation and attitudes toward chemistry.

Influence of other Factors

Based on the factors studied, some were not familiar to some authors. Different authors did not well explore these factors. For example, the perceived difficulty of science/chemistry was found in one study (Khan & Ali, 2012), where the majority (65%) of the students revealed that its nature complicates chemistry. Conceivably, this reflects students' inability to remember the basic concepts in chemistry, and they found it challenging to study. Some students do not get support from home, teacher, or school. This led them to become uninterested in the chemistry lesson and consider it irrelevant. Based on other studies, this may be due to some needed concepts in their future careers. Some may only consider the dangers caused by chemicals like toxicity, flammability, or other adverse effects on the environment without considering its advantages. The said factors may contribute to the perceived difficulty of chemistry and hence a decline in chemical education. These results are in congruent with the findings found in another study on students' attitudes toward chemistry, in which most of the students responded that chemistry is not an easy subject, reason why 66.7% were not planning to choose chemistry at the A2 level (Mahdi, 2014).

Few studies (Inye, 2011; Yunus & Ali, 2018) involved students' interest and self-directed effort (Liaghatdar et al., 2011). These factors are among the essential factors in determining students' attitudes and achievement in science. It is because students who are interested in following science subjects need to make more efforts to learn and understand some of the concepts being taught; they are highly motivated towards the particular subject and hence tend to maximize in the performed tests or exams (Hofstein & Mamlok- Naaman, 2011). Furthermore, Yunus and Ali (2018) noted that the students' achievement in the subject depends on their effort and level of interest to score high in chemistry exams. This is in line with the findings of George (2000), who state that students' perceptions of their ability in science influence their attitudes toward science.

This review indicated that there was a variability of researchers on different factors affecting students toward chemistry learning. This implies that the most studied factors may have been problematic in affecting students' attitudes in different fields. Therefore, the researchers desired to find out their effect on students' attitudes toward science in general and chemistry in particular. However, some authors might have known the least studied factor, but they were not studied due to different reasons. This was probably due to no supporting literature, lack of empirical studies conducted to investigate their effect on students' attitudes, hence limited in number, and they must therefore be recommended to future researchers.

CONCLUSION

From the review study conducted, the findings explored some of the common factors contributing to the attitudes of students toward learning chemistry. The results showed that before improving students' attitudes, it is essential to recognize the roots of the negative attitudes (Kubiatko et al., 2017). The important factors contributing to students' attitudes toward chemistry include gender, instructional methods, and grade levels. The majority of the authors studied the gender difference, and the findings reported that male students develop favorable attitudes toward chemistry compared to females. Therefore, it is recommended to teachers, school administrators, parents, and the community to support students developing positive attitudes, particularly female students, by addressing all the issues that affect their attitudes. The use of chemical aids and chemistry experiments should be encouraged in the learning process as they stimulate students to generate a positive attitude (Yunus & Ali, 2018). Also, the implementation of learning strategies involving problem-based learning or project-based learning through which students find the relevance of the subject in their daily life could change the perception of chemistry among students (Eilks & Marks, 2008). The study recommends that future researchers focus on factors including self-directed effort, students' interest, teaching aids and availability of infrastructure, and relevance of curriculum, which should also provide more information on learning chemistry.

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