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Student Attitudes towards Chemistry: an Examination of Choices and Preferences

Jassem G. Mahdi*

Department of Medical Sciences, College of Medicine, Shaqra University, Saudi Arabia
Corresponding author: jmahdi@su.edu.sa

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Abstract Chemistry is one of the foundations of science, technology and industry. It forms the fundamentals of the life sciences. This study, aims to investigate what make students choose or not to choose Chemistry and what are the main factors that contribute to the understanding of Chemistry as a subject? Four aspects were used to appraise students' attitudes towards Chemical education, including student's perceptions toward Chemistry, the concept of chemical knowledge and its understanding, application of chemical knowledge and understanding and career, help and school, using a questionnaire technique. Respondents indicated that students were positive with most statements to support their education, despite the perception that Chemistry is a difficult subject. Furthermore, respondents indicated that Chemistry is an interesting and not a boring subject, which certainly demands more attention to raise its status. Having help at home and from teachers were important factors that play significant roles in the student's preference to Chemistry but there is a disfavoured option for various careers, which may hinder student's interest in Chemistry.

Keywords: *Chemistry, education, perception, concepts, college, quantitative approach*

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1. Introduction

Chemistry is one of the main subjects that encompass valuable activities. Nonetheless, many instructors and learners consider Chemistry difficult to teach and to study. It plays an important role in the socio-economic development of various industries, including pharmaceuticals and petrochemicals. Chemistry, also is a requirement to study medicine, pharmacy and environment. However, the rate of student enrolment at college and university has been reported to be declined since 1993 in Britain [1,2,3]. Therefore, the aim of this study is to analyse the student's choices and preferences in studying Chemistry at Advanced Subsidiary (AS).

2. Study Rationale

Chemistry is a supportive subject for various disciplines, including pharmacology, physiology, clinical, chemical industry and environment. It appears from the literature that the general perception of chemical education for many people have been described as challenging and difficult to understand. This may be related to the fact that Chemistry involves different terminologies, structures and calculations. The learning of these elements, for many teachers and students may cause different levels of difficulties. These challenges and difficulties have been addressed in the literature to require a considerable attention [4]. He maintained that chemical education has been in a depressing state for 40 years. He reflected the state of chemical education by quoting the following

I was never any good at Chemistry; *I never understood atoms and molecules*; *I enjoyed splashing about in the laboratory, but I did not understand what I was doing* ([4] p. 34).

These and other results were lead the Royal Society of Chemistry (RSC), in their meeting on 22 January 2002, to address the following question: *Does Chemistry have a future*? [2].

The decline rate of Chemistry at university level may involve intrinsic (self) and/or extrinsic (school, teacher) factors at both the General Certificate of Secondary Education (GCSE) and Advanced level (A-levels) to encourage students undertaking Chemistry subject further. In this respect, many educational institutions recognise the importance of both teacher and student roles in the educational process, whereas, both contribute to the process outcome. Moreover, managing an effective learning process is often complex. Indeed research in the *individualising* of learning has not come up with a distinct specific technique(s) that can be applied to teaching [5,6]. In contrast, researches in the last four decades have studied the elements that are able to support effective learning. The results have indicated that students understanding and application of knowledge (cognitive) should be based on thinking and organisation of knowledge, not on studying hard and practice [6,7]). The

modern didactic teaching methods that involve demonstrations, modules and simulation are necessary for building up the subsequent levels of interaction. The use of different chemical modules, for example, allows effective individualization of teaching Chemistry, with the aim of promoting an effective learning process [8].

In addition, both internal and external factors can influence the educational process. The quality of the teaching/learning process is the main internal factors while surroundings, business and politics are the main external factors. Although these factors are inter and intra-act with each other in a complex manner, the main concern for the negotiated assignment is to analyse the student's perceptions on how they perceive Chemical Education. The effective teaching performance should consider the learning needs of the student's. The other criterion for managing effective learning is to create positive attitudes to learning and establish an assessment approach that reflects the insight of the learning process [5].

The aim of the didactic theory in Chemical Education is to facilitate the appropriate understanding of different aspects in Chemistry. Schooling at different stages follows theoretical models for the purpose of the application of these concepts later in students' perspective professions. The end product of studying must provide a minimum standard for students to apply the pedagogical concept in effective problem-solving. An effective teaching and learning process is most likely to occur when students are able to analyse problems, think critically and communicate their findings. Thus, maximising the educational outcome is not a one-way process, and involves the pedagogical effort and knowledge of teachers and students, at which both are subject to different environments and effectors.

Hence, didactic recourses help to learn Chemistry cognitively and psychometrically. Furthermore, learning Chemistry can also be active when knowledge is organised in a meaningful pattern and reflects a deep understanding of the subject. Therefore, the role of the Chemistry teacher is important as they need to establish an effective learning environment that is relevant to the capabilities of the students to construct their own knowledge. The essence of teaching and learning Chemistry is the ability of the teacher to provide experiences that share their expert meanings with novice learners [9]. These expert meanings include not only concepts, but also knowledge about how to learn Chemistry [9].

3. Methodology

The current study adopts the quantitative approach to examine student choices and preferences toward studying Chemistry at AS level. In this approach, the questionnaire technique was used to collect data [10]. This technique possess different advantages, including reliability compared with the interview method, as it is anonymous; it encourages greater honesty, and more economical in terms of time and money [11,12]

The construction of the questionnaire was aimed to achieve an effective instrument and establish sound criteria to reflect the aim and purpose of the current study. In addition, literature indicated that there is no reason why research objectives cannot be achieved if they are formulated before the questionnaire is designed [13].

The questionnaire instrument for this study includes two-section: the independent and dependent variables. Each of them comprised several questions or statements, in closed-ended form. The structure of the questionnaire is described as below:

1. Independent variables section includes three general questions related to student achievements in GCSE Science and whether students are studying Chemistry or not.

2. Dependent variables includes four sets of statements, including student's perceptions into Chemistry, The concept of chemical knowledge and understanding, application of chemical knowledge and understanding, career, help and school.

Respondents were requested to select the appropriate levels for the extent of agreement for 21 statements using three-point scale. The method involved an ascending scale of statement and consequence the agreement which were put in a three-point (i.e. 1- *agree*; 2- *not sure*; 3- *disagree*) scale order.

The sample population was selected according to the belief that they would be able to reflect the broad perspective of the perceptions to chemical education. Therefore, 70 AS students were selected from a population of 164. The sample population were all AS students at different schools in Cardiff, UK.

70 questionnaire forms were distributed in two ways; via email and in person. MSN Messenger Service was used to encourage students to complete the questionnaire. Only 36 questionnaire forms, or 51.4%, where returned completed. All data obtained from the questionnaire was transformed into numerical values and fed into the computer using SPSS for Windows, and results were then interpreted statistically. To determine whether variables were statistically significant, the significance level of 0.05 or more were used to indicate the probability of committing a type 1 error of 5% or less, based on a two-tailed test.

4. Results and Data Analysis

Results indicated that the mean values ranged between 2.33 (or not sure option) to 1.5 (or agree option). Student perceptions into Chemistry indicated that most students agreed that Chemistry is an interesting subject (statement 3A; 23, or 63.9%), it involves too many chemical formulas and is difficult to remember (statement 5A, 22, or 61.1%) and it is a challenging subject (statement 7A, 21, or %). 58.3%). However, responses to other statements in the other 3 sections (B, C and D, Table 1) were approximately equally distributed between the three options (agree, not sure and disagree), except in two statements where the majority of students agreed: *to apply chemical knowledge and understand familiar and unfamiliar situations require long hours of studying* (23, or 63.9%) (3C, Table 1), and *knowing that there will be a lot of help offered by the teachers and the school helps me to decide whether to take Chemistry* (25, or 69.4%) (5D, Table 1).

Results of the independent variables indicated that most students had B or C or less in their GCSE science exam

(Table 2). Most of them (14, or 38.9%) claimed that they did well in Chemistry (Table 1). Respondents were slightly more in favour of students that were not studying Chemistry (19, or 52.8%) compared to those who are taking Chemistry (17, or 47.2%) at AS level (Table 2). Most students (24, or 66.7%) were not planning to carry on studying Chemistry at A2 level (Table 2). These results suggest that student's perceptions were likely to assist in establishing both the necessary background data and the concept related to student choices in choosing to study advanced Chemistry. Results showed students planning to take A2 (12, or 33.3%) had A-A* grade in GCSE (8, 22.2%) (Table 2). Table 1 also shows the overall frequencies and the means of responses concerning the students' Chemistry education at college level.

Table 1. shows the frequencies, overall mean values and standard deviation of students responses to the 21 statements (N = 36) (1- agree; 2- Not sure, 3- disagree)

		1	2	3	Mean	Std. Dev
1A	Chemistry is an easy subject.	10	7	19	2.3333	0.7928
2A	Chemistry is a difficult subject.	12	9	15	2.2500	0.8742
3A	Chemistry is an interesting subject.	23	8	5	2.1667	0.8452
4A	The mathematics involved makes it not easy to understand.	14	11	11	2.1111	0.8545
5A	There are too many chemical formulas that are difficult to remember.	22	5	9	2.0833	0.8742
6A	The practical part of a Chemistry lesson encouraged me to take it.	19	8	9	1.6389	0.8333
7A	Chemistry is a challenging subject that is why I like it.	21	7	8	2.0556	0.9840
8A	Chemistry is a boring subject that is why I do not like it.	7	10	19	2.0556	0.9241
1B	It is not easy to recall facts, terminology and relationships.	14	11	11	1.9722	0.8779
2B	It is tricky to understand chemical principles and concepts.	14	11	11	1.9444	0.8600
3B	It is difficult to draw on existing knowledge to show an understanding of the responsible use of Chemistry in society.	14	11	11	1.9444	0.9241
4B	It is not easy to select, organise and present chemical information clearly and logically.	11	10	15	1.9167	0.8409
1C	Explaining and interpreting chemical principles and concepts are not easy.	14	10	12	1.9167	0.8409
2C	Chemistry is a complex subject and data are not easy to present.	14	6	16	1.9167	0.8409
3C	To apply chemical knowledge and understand familiar and unfamiliar situations require long hours of studying.	23	4	9	1.9167	0.8409
4C	It is complicated to make connections between different topics.	10	10	16	1.7222	0.8489
1D	I considered taking Chemistry because there will be help offered at home.	16	6	14	1.6389	0.8333
2D	I considered taking Chemistry for a future career.	16	2	8	1.6389	0.8669
3D	The teacher at GCSE built up my interest.	14	9	13	1.6111	0.8028
4D	Having a good teacher persuades me to carry on with Chemistry.	21	8	7	1.6111	0.8711
5D	Knowing that there will be a lot of help offered by the teachers and the school helps me to decide whether to take Chemistry.	25	6	5	1.5000	0.7368

Table 2. Respondents by GCSE graduates

GCSE Grade		Achievement		Student selection		Student planning	
Category	Freq.(%)	Category	Freq. %	Category	Freq. %	Category	Freq., %
A-A*	15 (41.7	Well	12 (33.3)				
B	13 (36.1	Good	10 (27.8)	Yes	19 (52.8)	Yes	24, (66.7)
C or less	8 (22.2	Poor	14 (38.9)	No	17 (47.2)	No	12, (33.3)
Total	36 (100		36 (100)		36 (100)		36 (100)

Cross-tabulating analyses showed differences (agree/disagree) between the two groups of respondents that are studying or not studying Chemistry over issues related to competence in Chemistry. Table 3 indicates that the majority of students (not studying Chemistry = 11, or 57.9%, studying Chemistry = 8, or 47.1%) disagreed with the *Chemistry is an easy subject* statement while the majority of students (12, or 70.6%) who are studying Chemistry disagree on *Chemistry is a difficult subject* statement (Table 3). Similarly the majority of Chemistry students (16, or 94.1%) thought that *Chemistry is an interesting subject* (16, or 94.1%), *easy to understand* (9, or 52.9%), *challenging subject* (15, or 88.2%) and *is not a boring subject* (14, or 82.4%) (Table 3). These results may indicate that students have set up their preferences to fit their future planning.

Table 3. Cross tabulation of are you studying Chemistry as an AS *versus* dependent statements related to students' *perception into Chemistry*

		agree	not sure	disagree	Total	Sig. (2-sided)*
	Chemistry is an easy subject (1A)					
Are you studying Chemistry as an AS?	Yes(%)	7(41.2)	2(11.8)	8(47.1)	17(100)	0.196
	No(%)	3(15.8)	5(26.3)	11(57.9)	19(100)	
	Chemistry is a difficult subject (2A)					
	Yes(%)	4 (23.5)	1 (5.9)	12 (70.6)	17 (100)	0.002
	No(%)	8 (42.1)	8 (42.1)	3 (15.8)	19 (100)	
	Chemistry is an interesting subject (3A)					
	Yes(%)	16(94.1)	0 (0.0)	1(5.9)	17(100)	0.001
	No(%)	7(36.8)	8(42.1)	4(2.1)	19(100)	
	The mathematics involved makes it not easy to understand (4A)					
	Yes(%)	4(23.5)	4(23.5)	9(52.9)	17(100)	0.021
	No(%)	10(52.6)	7(36.8)	2(10.5)	19(100)	
Are you studying Chemistry as an AS?	There are too many chemical formulas that are difficult to remember (5A)					
	Yes(%)	10(58.8)	2(11.8)	5(29.4)	17(100)	
	No(%)	12(63.2)	3(15.8)	4(21.1)	19(100)	0.826
	The practical part of a Chemistry lesson encouraged me to take it (6A)					
	Yes(%)	14(82.4)	3(17.6)	--	17(100)	
	No(%)	5(26.3)	5(26.3)	9(47.4)	19(100)	0.001
	Chemistry is a challenging subject that is why I like it (7A)					
	Yes(%)	15(88.2)	1(5.9)	1(5.9)	17(100)	
	No(%)	6(31.6)	6(31.6)	7(36.8)	19(100)	0.003
	Chemistry is a boring subject that is why I do not like it (8A)					
	Yes(%)	1(5.9)	2(11.8)	14(82.4)	17(100)	0.003
	No(%)	6(31.6)	8(42.1)	5(26.3)	19(100)	

*Pearson Chi-Square value respectively = 3.258, 12.104, 13.252, 7.757, 0.383, 13.694, 11.854, 11.359; degree of freedom for all = 2

Table 4 shows students perceptions into 4 statements related to the concept of chemical knowledge and understanding. The majority of students again have different views into Chemistry where students that are taken Chemistry were positive with the difficulty of Chemistry as a subject while students that are not studying Chemistry reflected negative views and, to a certain extent, thought Chemistry was a difficult subject. Responses to It is not easy to recall facts, term terminology and relationships indicated that there were 10 students not studying AS Chemistry who were positive to this statement. In contrast, 8 students or 47.1% of the students that are studying Chemistry were negative to statement 1B (Table 4). Results of responses into the other statements in this table show similar results.

Table 4. Cross tabulation of 'are you studying Chemistry as an AS' *versus* dependent statements related to 'the concept of chemical knowledge and understanding'

		agree	not sure	disagree	Total	Sig. (2-sided)*
	It is not easy to recall facts, terminology and relationships (1B)					
Are you studying Chemistry as an AS?	Yes(%)	4(23.5)	5(29.4)	8(47.1)	17(100)	0.089
	No (%)	10(52.6)	6(31.6)	3(15.8)	19(100)	
	It is tricky to understand chemical principles and concepts (2B)					
	Yes(%)	6(35.3)	4(23.5)	7(41.2)	17(100)	0.403
	No (%)	8(42.1)	7(36.8)	4(21.1)	19(100)	
	It is difficult to draw on existing knowledge to show an understanding of the responsible use of Chemistry in society (3B)					
	Yes(%)	5	4(23.5)	8(47.1)	17(100)	0.126
	No (%)	9(47.4)	7(36.8)	3(15.8)	19(100)	
	It is not easy to select, organise and present chemical information clearly and logically (4B)					
	Yes(%)	3(17.6)	1(5.9)	13(76.5)	17(100)	0.000
	No (%)	8(42.1)	9(47.4)	2(10.5)	19(100)	

** Pearson Chi-Square value respectively = 4.839, 1.817, 4.135, 16.680; degree of freedom for all = 2

Furthermore, Responses into the statements related to the application of chemical knowledge and understanding showed the same trend of answers in Tables (5). The majority of students in the two groups (studying or not studying Chemistry) also showed different views except for to apply chemical knowledge and understand familiar and unfamiliar situations require long hours of studying statement. Student in both groups showed positive views (Studying Chemistry = 10, or 58.8%, and not studying Chemistry = 13, 68.4%).

Table 5. Cross tabulation of 'are you studying Chemistry as an AS' *versus* dependent statements related to Application of Chemical Knowledge and Understanding

		agree	not sure	disagree	Total	Sig. (2-sided)*
Are you studying Chemistry as an AS?	Explaining and interpreting chemical principles and concepts are not easy (1C)					
	Yes (%)	4(23.5)	3(17.6)	10(58.8)	17(100)	0.009
	No (%)	10(52.6)	7(36.8)	2(10.5)	19(100)	
	Chemistry is a complex subject and data are not easy to present (2C)					
	Yes (%)	3(17.6)	4(23.5)	10(58.8)	17(100)	0. 046
	No (%)	11(57.9)	2(10.5)	6(31.6)	19(100)	
	To apply chemical knowledge and understand familiar and unfamiliar situations require long hours of studying (3C)					
	Yes (%)	10(58.8)	1(5.9)	6(35.3)	17(100)	0.000
	No (%)	-	3(15.8)	3(15.8)	19(100)	
	It is complicated to make connections between different topics (4C)					
	Yes (%)	0(0.0)	4(23.5)	13(76.5)	17(100)	0.000
	No (%)	10(52.6)	6(31.6)	3(15.8)	19(100)	

* Pearson Chi-Square value respectively = 9.423, 6.146, 2.287, 16.590; degree of freedom for all = 2

Table 6 includes the results of five statements related to career, help and school. The cross-tabulation analysis of most of these issues is consistent with the overall perceptions into the issues mentioned and analysed in the previous three tables. The vast majority of AS Chemistry students (13, or 76.5%) agreed in the importance of help that they may receive at home. Likewise, students agreed that they are taking Chemistry for their future careers and the role of the teacher at GCSE level in building up their interest in Chemistry. Furthermore, both groups of students agree with the importance of the role of both teacher and school in helping to decide whether to take Chemistry.

The above results in the four sections of the dependents variables have clearly showed that students differ in their views related to Chemistry education. The overall responses to the 21 statements also showed that between 2-11% of the students responded to statements by *not sure* while 3-7% of the minority of students in each group have taken the same view of the other group (studying/not studying Chemistry).

Table 6. Cross tabulation of statement 'are you studying Chemistry as an AS' *versus* dependent statements related to Career, help and School

		agree	not sure	disagree	Total	Sig. (2-sided)*
Are you studying Chemistry as an AS?	I considered taking Chemistry because there will be help offered at home (1D)					
	Yes (%)	13(76.5)	1(5.9)	3(17.6)	17(100)	0.001
	No (%)	3(15.8)	5(26.3)	11(57.9)	19(100)	
	I considered taking Chemistry for a future career (2D)					
	Yes (%)	11(64.7)	1(5.9)	5(29.4)	17(100)	0.057
	No (%)	5(26.3)	1(5.3)	13(68.4)	19(100)	
Are you studying Chemistry as an AS?	The teacher at GCSE built up my interest (3D)					
	Yes (%)	8(47.1)	6(35.3)	3(17.6)	17(100)	0.0871
	No (%)	6(31.6)	3(15.8)	10(52.6)	19(100)	
	Having a good teacher persuades me to carry on with Chemistry (4D)					
	Yes (%)	9(52.9)	4(23.5)	4(23.5)	17(100)	0.462
	No (%)	12(63.2)	4(21.1)	3(15.8)	19(100)	
	Knowing that there will be a lot of help offered by the teachers and the school helps me to decide whether to take Chemistry (5D)					
	Yes (%)	14(82.4)	1(5.9)	2(11.8)	17(100)	0.215
	No (%)	11(57.9)	5(26.3)	3(15.8)	19(100)	

*Pearson Chi-Square value respectively = 13.418, 5.712, 4.959, 0.462, 3.125

5. Discussion and Conclusion

The results of the questionnaire in the previous section attempted to answer the research question in the title: Why do students like to study Chemistry? The data was derived from 36 respondents out of 70 questionnaire sheets that were distributed to AS students at different schools in Cardiff. The results include four independent and twenty one dependent variables related to four aspects: (1)- students' perceptions into Chemistry, (2)- the concept of chemical knowledge and understanding, (3)- application of chemical knowledge and understanding and (4) career, help and school. Cross-tabulation analysis was used to investigate students' perception according to whether they were studying Chemistry or not.

Responses to different statements were analysed by cross-tabulation of the subject preference (i.e. are you studying Chemistry as an AS? (Yes or No) and the responses to the twenty-one statements. Both frequencies and percentages were used to express and discuss the results. Although, results of the cross-tabulation showed clear distinction in student's options in the 3-point scale, chi-square analysis confirmed the statistical differences between subject preferences on most issues (Table 3-Table 6). Generally cross-tabulation analysis indicated that students studying Chemistry were positive with the relevant statements, while students who chose not to study AS Chemistry were negative towards relevant issues. Perhaps, this reflects the students' awareness to what they chose to study to support their future plan or according to what they can do. The differences in the perceptions of

students to chemical education were confirmed by chi-square as shown in Table 7. Results of chi-square showed that students were significantly differed on 10 statements, or 47.6% of the total statements (N= 21).

These results indicated that students studying AS Chemistry were significantly different in their perceptions from their peers who were not studying Chemistry. However, the majority of both groups thought that Chemistry is not an easy subject to study. This may be a wide held view amongst other students who have not participated in this study. Some students have to take Chemistry because of the demands of the degree schemes they would like to follow. Hence, chemical education certainly demands more attention to be given to a greater diversity of activities and skills such as mainly numeracy experimental work. A didactic approach may well prove useful in attempting to increase the popularity of the discipline amongst students. Indeed, in this study about 36.9% of students in the two groups thought that Chemistry is an interesting subject and 52.8% of respondents believed that Chemistry is not a boring subject. However, there is a consensus that Chemistry is a disfavoured option for various careers compared to other subjects, like Maths, English, Business and other social subjects. Some studies suggest that students entering college no longer perceive physical sciences, such as Chemistry to be either desirable or achievable as career aspirations [14]. This notion may support responses to the following statement: *I considered taking Chemistry for a future career* (2D), where 64.7% of AS Chemistry students.

Furthermore, the results have indicated that the help students may receive from home, teacher or school may contribute to increase student's interest in Chemistry. Indeed these features are not separate entities in themselves. These factors can be seen as corresponding directly to yield the increased interest given. For example, an individual who is attracted to the field through positive role models is more likely to consider Chemistry as a career and thus be further interested in the field.

There are various factors that contribute to the image of Chemistry as a discipline. Organic plant products, a 'chemical-free garden and other terms that are frequently used for advertisement purposes may contribute inversely to chemical education. Furthermore, it has become apparent that chemicals are dangerous whether because of toxicity, flammability or some adverse effects on the environment, which may participate in the association of the public that Chemistry is dangerous. All these factors may contribute to chemical education declining [2].

In conclusion although the number of respondents was only 36, the statistical analysis and the overall results have highlighted some important factors that are associated with student's preferences in chemical education.

Table 7. Chi-square results of statements that showed statistical differences

Statement	Chi-Square	DF	Sig. (2-sided)*
Chemistry is a difficult subject (2A)	12.104	2	0.002
Chemistry is an interesting subject (3A)	13.252	2	0.001
The mathematics involved makes it not easy to understand (4A)	7.757	2	0.021
The practical part of a Chemistry lesson encouraged me to take it (6A	13.694	2	0.001
Chemistry is a challenging subject that is why I like it (7A)	11.854	2	0.003
Chemistry is a boring subject that is why I do not like it (8A)	11.359	2	0.003
It is not easy to select, organize and present chemical information clearly and logically (4B)	16.680	2	0.000
Explaining and interpreting chemical principles and concepts are not easy (1C)	9.423	2	0.009
It is complicated to make connections between different topics (4C)	16.590	2	0.000
I considered taking Chemistry because there will be help offered at home (1D)	13.418	2	0.001

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