Exploring Difficulties in Chemistry School in Emirates

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دورية علمية محكمة نصف سنوية
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In the fourth study new teaching material were designed (four booklets). For this stage, a total sample of 800 students boys and girls was selected. Each pupil completed one section of the syllabus using the new material. It was thus possible to use half the students in each year group as an experimental group and half as a control for each new material booklet, thus ensuring that there was no possible bias in the groups which had to be selected to meet the actual classes being taught.

The work was carried out over two terms. Two booklets were used in November-December 2004, one entitled 'The Periodic Table of Elements' (for one half of year 10), the others entitled 'Organic Chemistry' (for one half of year 11). The other two booklets were used in March-April 2005: 'Chemical Equation' for year 10 and 'Acids & Alkalis' for year 11, these being used with the other half of each year group respectively. This meant that the experimental group which worked with the booklets in November-December 2004 , became the control group in March-April 2005 for both year groups.

Chemistry tests were applied after completing the various sections of the syllabus and the results compared, for each topic, to see if the groups who had used the new materials were performing better than those who had been taught in the traditional way The attitudes of the students were also measured using the same questionnaire which had been used in February 2003, with the previous year groups. This was completed in April 2004.

From the t-test results, there was a quite marked improvement in performance with the use of all four booklets ($p < 0.001$) while the students attitudes also had become more positive, the effect being extremely marked (chi-square values sometimes were more than 100 which is very unusual).

Specific Findings

The results from the two grid tests in experiment 1 suggest that many students have not grasped some of the basic ideas of chemistry. The results leave an impression that students have memorised some things but do not really understand what it is all about. Chemistry is abstract and they have no 'feel' for the nature of chemicals. If students have not mastered some of the basic skills, then it reduces chemistry to an abstract subject to be memorised. Perhaps it is little wonder that attitudes are not too positive.

The general impression left from both year groups is that here there are students who are well aware of the importance and significance of chemistry but who find the whole learning experience highly unsatisfactory. The data tend to confirm the need to make a curriculum closely related to context and lifestyle of learners.

The improvements in the means scores obtained after using the new teaching materials are very large. The effectiveness of the new teaching material has therefore been shown to bring about a very marked consistent improvement in the performance of students. Two features were deliberately used to underpin the design of the new materials: reducing the working memory load and relating new material to the experiences and previous knowledge of students

Attitudes towards chemistry and, indeed, towards learning, are likely to be important factors influencing success. In almost every measure made, the students who used the new materials have demonstrated more positive views when compared to the equivalent group from the previous year. The size of the attitude change is all the more remarkable in that each group had only undertaken one chemistry teaching unit using the new materials.

For the third stage of this study, two questionnaires to explore attitudes towards chemistry were developed, one for year 10 and the other for year 11. Overall, they aimed to see how attitudes are related to their experiences of difficulties. For this stage, a total sample of 225 students in two typical Emirates schools were involved, one boys' and one girls' . The questionnaires were distributed among year 10 and year 11 students in February 2003. Together, these surveys gave an overall picture, with large samples, of the situation in chemistry in the Emirates and provided clear guidance for the next stage of the work.

Finally, the most important design feature to influence results was that questions in the materials often started by providing information rather than asking the students to recall information The aim was to develop and test skills of understanding, interpretation and seeing things in context.

Care was taken in designing the test material to ensure that it covered the key elements of the syllabus and did not favour one group or the other.

A Review of the Study and Conclusions

In the light of what was found, new teaching materials were developed and their effectiveness were tested. There were two main aims in designing the new materials. The first aim was to seek to reduce the difficulties the students were experiencing. The second was to seek to develop more positive attitudes towards their studies in chemistry. An information processing model predicted that the difficulties were likely to be caused by working memory overload. A key design feature in the construction of the new materials was to re-structure the way the material was presented as that working memory overload was minimised.

Previous work on attitude development has shown that attitudes are more likely to develop if the learners interact mentally with the issues involved (Reid, 1978) while more recent work (Reid and Skryabina, 2002) has shown that attitudes towards a subject are likely to be much more positive if the subject matter is presented in such a way that its context and significance are directly related to the learner. Given the limitations of written material, the aim was to design the materials in such a way that these two criteria were met, at least in part.

In the first stage, two survey forms were developed, one for year 10 and the other for year 11, to identify the areas of greatest difficulty. A total sample of 490 students, boys and girls, were drawn from two large typical secondary schools in the United Arab Emirates, one a girls' school and one a boys' school. The surveys were completed in May 2002, towards the end of the year's teaching,.

In the second stage of this study, the areas of greatest difficulty were explored further using Structural Communication Grid questions, one for year 10 and the other for year 11. For this stage, a total sample of 318 students was selected again drawn from two secondary schools in the United Arab Emirates, one a girls' school and one a boys' school. The surveys were completed in October 2002.

Figure 8

$CaCl_2$

→ 2 x 35.5 = 71g

→ 1 x 40 = 40g

Total = 111g

Figure 7

$(NH_4)_2SO_4$

→ 4 x 16 = 64g

→ 1 x 32 = 32g

→ 2 x 4 x 1 = 8

→ 2 x 1 x 14 = 28

There are **two** NH_4 groups:
This means **two** nitrogen atoms
and **eight** hydrogen atoms

Total = 132g

Figure 6

1776 $_{1}$H																	1895 $_{2}$He
1817 $_{3}$Li	1828 $_{4}$Be											1808 $_{5}$B	$_{6}$C	1772 $_{7}$N	1776 $_{8}$O	1886 $_{9}$F	1898 $_{10}$Ne
1807 $_{11}$Na	1808 $_{12}$Mg											1827 $_{13}$Al	1824 $_{14}$Si	1669 $_{15}$P	$_{16}$S	1774 $_{17}$Cl	1894 $_{18}$Ar
1807 $_{19}$K	1808 $_{20}$Ca	1876 $_{21}$Sc	1791 $_{22}$Ti	1801 $_{23}$V	1797 $_{24}$Cr	1774 $_{25}$Mn	$_{26}$Fe	1735 $_{27}$Co	1751 $_{28}$Ni	$_{29}$Cu	1746 $_{30}$Zn	1875 $_{31}$Ga	1886 $_{32}$Ge	1649 $_{33}$As	1817 $_{34}$Se	1826 $_{35}$Br	1898 $_{36}$Kr
1861 $_{37}$Rb	1808 $_{38}$Sr	1828 $_{39}$Y	1824 $_{40}$Zr	1801 $_{41}$Nb	1782 $_{42}$Mo	1937 $_{43}$Te	1844 $_{44}$Ru	1803 $_{45}$Rh	1803 $_{46}$Pd	$_{47}$Ag	1817 $_{48}$Cd	1863 $_{49}$In	$_{50}$Sn	1620 $_{51}$Sb	1782 $_{52}$Te	1811 $_{53}$I	1898 $_{54}$Xe
1860 $_{55}$Cs	1808 $_{56}$Ba	1839 $_{57}$La*	1923 $_{72}$Hf	1903 $_{73}$Ta	1783 $_{74}$W	1925 $_{75}$Re	1803 $_{76}$Os	1803 $_{77}$Ir	1735 $_{78}$Pt	$_{79}$Au	$_{80}$Hg	1861 $_{81}$Tl	$_{82}$Pb	1753 $_{83}$Bi	1898 $_{84}$Po	1940 $_{85}$At	1900 $_{86}$Rn
1939 $_{87}$Fr	1898 $_{88}$Ra	1889 $_{89}$Ac**															

Previous work has shown again and again the influence of working memory on examination performance. In this study, the teaching material was deliberately designed to reduce working memory overloading. The results are quite remarkable.

An example of the whole approach can be seen in the chemical calculations section (see figures 7 and 8). These new methodologies played a central role in the results. Indeed, using appropriate applications, illustrations and colours was aiming to make chemistry fun and this may also have played an important role in the results.

The improvements in the means scores obtained are very large. The effectiveness of the new teaching material has therefore been shown to bring about a very marked consistent improvement in the performance of students. There is a possibility that the material, being new and different, generated greater interest, simply on grounds of novelty. However, it is unlikely that this would have caused such a great improvement.

Two features were deliberately used to underpin the design of the new materials. Firstly, the materials aimed to be attractive, with diagrams, linked to everyday experience enabling students to build on existing knowledge and enabling them to assimilate and transfer new learning into long-term memory. An example includes the new design of the periodic table, simply offering the symbol and date of discovery (see figure 6) and then setting exploratory tasks preventing information overload and encouraging an investigative approach. This was the second factor: the reduction of information overload. By carefully sequencing the ideas introduced and presenting them step by step, the aim was to avoid situations where the amount of information to be handled at any one time exceeded the working memory capacity of the learners.

t-test Values and Differences in Means

		t-test value	Differencs in Means
Year 10	Periodic Table	26.33	18
	Equations	9.66	9
Year 11	Organic Chemistry	19.65	14
	Acids and Alkalis	15.10	11

Table8t-test values and Differences in Means

(i)What is the hydrogen ion concentration in the blood of a *normal* person?
(ii)What is the hydrogen ion concentration in the blood of the very *ill* person?
(iii)How much *more* hydrogen ion is present in the blood of the very sick person?

Experimental GroupControl Group

0.7 0.7

There is not any different performance between two groups in this question.

Q5 You have a litre of 0.1M HCl (pH = 1) and a litre of 0.01M NaOH (pH= 12). The two solutions are mixed. What is the likely pH of the final solution. (Do not attempt any calculation).

Tick one box

10.90	7.00	6.50	1.35	0.95

Experimental Group Control Group

0.8 0.5

This question can be answered with more or less no calculation. It seeks to test if the students really can conceptualise neutralisation related to pH change. The new materials have made a quite enormous difference in performance. The students using these materials have now a much more intuitive grasp of the ideas involved.

Q6 Look at the following table:

Indicators	Colour change	pH interval
Methyl orange	Orange- Yellow	2.1- 4.4
Methyl red	Red - Yellow	4.2 - 6.3
Bromthymol blue	Yellow - Blue	6.0 - 7.6
Phenolphthalein	Colourless - Red	8.3 - 10.0

(a)Choose the best indicator for a titration of sodium hydroxide and sulphuric acid,given that sodium sulphate has a pH of 7.

Experimental Group Control Group

0.9 0.8

(b)Choose the best indicator for a titration of sodium hydroxide and ethanoic acid, given that sodium ethanoate has a pH of 9.

Experimental Group Control Group

0.9 0.9

There is no large differences in performance between two groups. Two groups cope with choosing indicators reasonably well.

Discussion

The t-values are very high and therefore the probability that the results happened by chance are extremely low. It is true that the experimental and control groups for each group were not matched as the researcher was restricted by the class organisation in schools. However, any variation resulting from this was eliminated as a factor, as each group acted as a control for one section of work and one test result only. Thus, the case for **being confident of the results has been strengthened enormously.**

(b) **Calculate the [H+] concentration in moles per litre for some drinking water which has a pH of 6.**

Experimental Group	*Control Group*
0.9	**0.9**

Q2 **(a)** **The [OH-] concentration in moles per litre is 0.001. What is the pH of the solution?**

Experimental Group	*Control Group*
0.7	**0.5**

(b) **In some pure water at 25oC, the [H+] and [OH-] are both 10-7 moles per litre. What is the pH ?**

Experimental Group	*Control Group*
1.0	**1.0**

Only one question is there difference in performance. The control group has difficulty to get pH by using [OH-] concentration. This means there is difficulty in connecting pH and pOH laws together.

Q3 **(a)** **Water from an underground source is found to have a pH of 4.3.**
What is the concentration of hydrogen ion in moles per litre?

Experimental Group	*Control Group*
0.7	**0.5**

(b) **A bottle of cleaning liquid has a pH of 10.**
What is the [H+] and [OH-] ?

Experimental Group	*Control Group*
0.7	**0.6**

Large differences between the two groups are observed. The new material has really made change to the ability to relate pH to ion concentrations.

Q4 **(a)** **Some brands of liquid soap, for use in having a shower, state that they have a pH of 5.8. Suggest why 5.8 is chosen ?**

Experimental Group	*Control Group*
0.9	**0.9**

(b) **The pH value of Human blood is normally 7.4 .**
Suppose a very ill person's blood pH is found to have fallen to 6.4.

Question 2 required the students to balance several equations:

Experimental. Group Control Group

0.9 0.7

Question 3 required the students to calculate formula masses

Experimental. Group Control Group

0.9 0.9

Question 4 involved calculations relating to mass and moles:

Experimental. G. Control G.

(a) The mass of a mole of sulphuric acid (H2SO4) 0.8 0.7

(b) Number of moles of ammonia (NH3) in 68g of ammonia 0.7 0.5

In only questions 1 and 2 is there difference in performance. It is clear that the control group has more difficulty in writing formulae and balancing equation. The results reflect that the experimental group's better performance in calculations of mass and moles. The different approach adopted in the new material clearly has proved effective.

Test: Acids and alkalis

Table 7 shows the comparison of the experimental group and control group with year 10 students in the grid test on '*Acids and alkalis*'.

Table 7 Experimental group and control group
'*Acids and alkalis*'

Acids and Alkalis									
Experimental Group					*Control Group*				
N	*Mean*	*S.D.*	*Max*	*Min*	*N*	*Mean*	*S.D.*	*Max*	*Min*
200	75.0	6.51	94	59	200	64.3	7.48	88	47
t -test	t = 15.1		p < 0.001						

The same situation occurs in the 'Acids and alkalis' grid test. There was a very significant difference between the mean scores achieved by the experiment group and the control group ($t = 15.1$, $p < 0.001$). Again, the experimental group performed significantly better than the control group in the 'Acids and alkalis' test.

Q1 (a) Calculate the pH of 0.01 mole per litre hydrochloric acid solution.

Experimental Group Control Group

1.0 0.9

The data showed that there was a very significant difference in chemistry achievement in the topic 'The Chemical Equation' between the mean scores achieved by the experiment group and the control group ($t = 9.66$, $p < 0.001$). Specific questions gave the following pattern.

Question 1 required the students to write formula for several compounds;

Experimental. Group Control Group

0.8 0.7

		Experimental Group	*Control Group*
(a)	**Isomers of the molecule shown in box B**	**0.78**	**0.81**
(b)	**Isomers of the molecule shown in box G**	**0.65**	**0.66**
(c)	**Isomers of the molecule shown in box H**	**0.67**	**0.70**
(d)	**Isomers of the molecule shown in box I**	**0.66**	**0.34**
(e)	**Isomers of the molecule shown in box J**	**0.73**	**0.56**

In only two questions is there a major difference in performance. The control group clearly has difficulty in seeing isomerism around a double bond.

Question 3

(a) Explain in three sentences why cracking is so important in oil industry?

Experimental Group	*Control Group*
0.8	**0.6**

(b) "Polymerisation is the opposite of cracking"
Write in three sentences how this is true?

Experimental Group	*Control Group*
0.8	**0.5**

The experimental group has a much better grasp of the oil industry

Test: Chemical Equations

Table 6 shows the comparison of the experimental group and control group with year 10 students in the test on '*Chemical Equations*'.

Table 6 Experimental group and control group
'*Chemical Equations*'

Chemical Equations									
Experimental Group					*Control Group*				
N	*Mean*	*S.D.*	*Max*	*Min*	*N*	*Mean*	*S.D.*	*Max*	*Min*
200	80.2	8.97	97	44	200	71	10.07	97	44
t -test	t = 9.66		p < 0.001						

Question 1

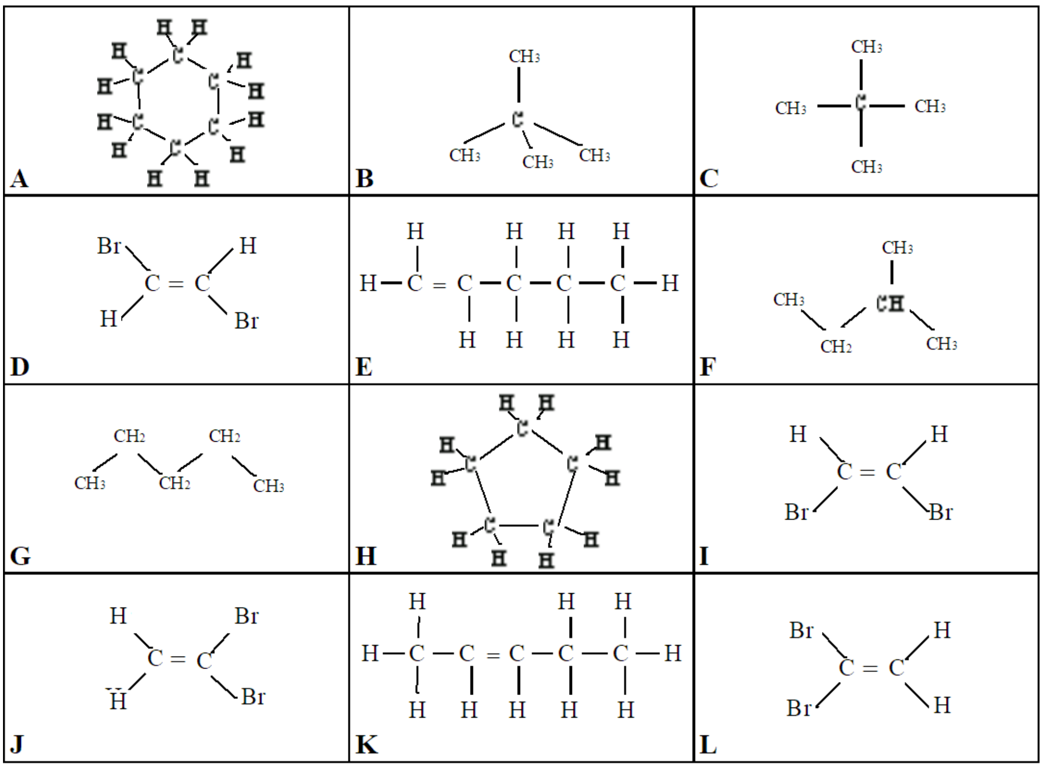
A C_2H_2	**B** C_3H_8	**C** CH_4
D C_5H_{10}	**E** C_4H_8	**F** C_7H_{16}
G C_3H_4	**H** C_7H_{14}	**I** C_6H_6

Select the box(es) which contain:

		Experimental Group	*Control Group*
(a)	**Alkanes**	**0.70**	**0.65**
(b)	**Alkenes**	**0.56**	**0.54**
(c)	**Alkynes**	**0.76**	**0.77**
(d)	**Cycloalkanes**	**0.60**	**0.63**

Large differences between the two groups are not observed. The new material has not really made any change to the recognition of hydrocarbon molecules

Question 2



Select the box(es) which contain:

Year 10 students were also invited to construct a concept map on the topic of 'The Periodic Table of Elements' as a way to gain an insight into the students' ideas lodged in long term memory.

They were then given a sheet of paper with the information as shown below. They were invited to draw as much as they could in the same way to show what they knew about the Periodic Table. A total sample of 400 students of year 10 boys and girls age 15-16 years were involved.

The 'Concept Map Marks' which were achieved by students in the experiment and control groups for year 10. An independent samples t-test was run to compare the experimental group to the control group in their performance on the concept map. This is shown in table 4

Table 4 t-test Results for Concept Maps

Periodic Table									
Experimental Group					*Control Group*				
N	*Mean*	*S.D.*	*Max*	*Min*	*N*	*Mean*	*S.D.*	*Max*	*Min*
200	11.9	1.68	18	9	200	11.5	1.04	14	8
t -test	t = 3.44			p < 0.001					

Assuming that the concept map marks do reflect the ideas held in long term memory and the links between these ideas, the experimental group's better performance suggests that they hold more ideas relating to the periodic table.

The marks for the maps were included in the test marks when the overall performance of the two groups was compared.

Test: Organic Chemistry

Table 5 shows the comparison of the experimental group and control group in the year 11 students' achievement in the grid test on '*Organic Chemistry*'.

Table 5 Experimental group and control group '*Organic Chemistry*'.

Organic Chemistry									
Experimental Group					*Control Group*				
N	*Mean*	*S.D.*	*Max*	*Min*	*N*	*Mean*	*S.D.*	*Max*	*Min*
200	71.0	6.70	95	57	200	57.0	7.44	83	42
t -test	t = 19.65			p < 0.001					

The same situation occurs in the 'Organic Chemistry' grid test with year 11. There was a very significant difference between the mean scores achieved by the experiment group and the control group (t = 19.65, p < 0.001). Again, the experimental group performed significantly better than the control group in the 'Organic Chemistry' grid test. Each question is now discussed in turn.

(c) In a group in the right order of atom size ? 0.8 0.6
(d) In a period in the right order of atom size ? 0.9 0.7

The new materials have brought abut consistent improvement. The most marked area of improvement is in grasping how electronegativity varies across a group.

Question 3

A K	B Ne	C Al	D Sr
E Na	F Rb	G F	H Br
I Cl	J Ca	K Ar	L Mg

Select box (es) which contain: *Experimental Group*
Control Group

(a) Elements which have 1 electron in the outer shell ? 0.9 0.4
(b) Elements which have 2 electrons in the outer shell ? 0.9 0.6
(c) Elements which have 7 electrons in the outer shell ? 0.9 0.5
(d) Electrons where the outer shell is completely full.0.7 0.7

This question shows a dramatic difference in performance in three parts. The new materials have been successful in enabling the students to understand the electronic arrangement in atoms correctly. The octet was not emphasised in the new materials (it is misleading) and there is no difference between the two groups in part (d).

Question 4

Experimental Group *Control Group*

In *one* sentence explain why a:

(a) Li atom is smaller than a Na atom? 0.9 0.9
(b) F atom is smaller than Cl atom ?. 0.9 0.9
(c) F atom is smaller than a Li atom? 1.0 0.9

Question 5 In *two* sentences explain why a Chlorine (Cl) atom is more electronegative than a Calcium (Ca) atom

Experimental Group *Control Group* 0.7 0.6

In questions 4 and 5, students are asked for explanations and the experimental group are only slightly better than the control group

0.7 0.6

The data showed that there was a very significant difference in chemistry achievement with year 10 (on topic: 'The Periodic Table of Elements') between the mean scores achieved by the experiment group and the control group ($t = 26.23$, $p < 0.001$).
Interestingly, questions 1(a), 1(b), 2(b) and 2(d) test ideas which are taught similarly to both groups and the response patterns are virtually identical. The mean marks (as facility values) are now shown for each part of each question for the two groups.

Question 1

A **Ne**	**B** **As**	**C** **Fe**	**D** **Li**
E **K**	**F** **Al**	**G** **Cl**	**H** **Ar**
I **F**	**J** **Mg**	**K** **Kr**	**L** **Na**

Select the box(es) which contain elements which:
Experimental Group Control Group

(a) Can show a valency of 2 ? 1.0 1.0
(b) Can show a valency of 3 ? 0.9 0.9
(c) Are non-metals? 0.7 0.1
(d) Are noble gases? 0.6 0.3
(e) Were known in ancient time? 0.8 0.1
(f) Are halogens? 0.8 0.5

The new materials have clearly offered to the students a much better grasp of the periodic table: recognising groups of elements. However, the ability of the students to recognise valency is unaltered.

Question 2

A **F > Cl > Br > I**	**B** **Cs > Rb > K > Na**	**C** **Sr > Ca > Mg > Be**
D **Be < Mg < Ca < Sr**	**E** **Li > Be> B > C**	**F** **Li < Be < B < C**

Select the box(es) which contain elements: ***Experimental Group Control Group***
(a) In a group in the right order of electronegativity ? 1.0 0.5
(b) In a period in the right order of electronegativity ? 0.8 0.8

The Periodic Table of Elements'

Periodic Table									
Experimental Group					*Control Group*				
N	*Mean*	*S.D.*	*Max*	*Min*	*N*	*Mean*	*S.D.*	*Max*	*Min*
200	79.2	4.84	95	60	200	61.0	2.16	85	43
t -test	$t = 26.23$			$p < 0.001$					

Analysis of Results

While structural communication grids can be marked like any other test, the strength of these tests is in exploring incomplete answers and looking closely at patterns of wrong answers. To do this, the student performance in each part of each question is converted into a code. The codes may have to be adjusted in the light of what is observed. The aim of these codes is to count the numbers of students under each code and this will give a picture of how students performed in each question. The codes were chosen to achieve these aims. The codes and scores which were used for 'The Periodic Table of Elements' and 'Organic Chemistry'.

The data were entered into a spreadsheet . The codes were converted into scores and a total score was obtained for each student for each test. In order to compare between the groups, an *independent t-test* was used. Here, the overall performance is compared between groups who had used the new teaching materials or who had been taught in the traditional way.

Test Results

The main aim of this study is to explore the performance of senior school students when they have been taught in a way which is consistent with information processing predictions related to successful learning and also consistent with the evidence about the development of positive attitudes. For the first purpose, the total scores in the four tests and the responses to the attitude survey are analysed.

However, it is possible to analyse the detailed responses in every a part of every question, especially when structural communication grids are used, to pinpoint specific areas where learning has been achieved successfully and specific areas where the students are showing consistent confusions. Where the pattern of responses in each part of each question suggested some interesting features, the response pattern was considered in more detail. This offers insights into the specific ways in which the new materials assisted students towards better understanding.

The results for each test are now discussed in turn, comparing the performance of the groups who used the new teaching material or who were taught in the traditional style.

Test: The Periodic Table of Element

Table 3 shows the comparison of the experimental group and control group in year 10 student achievement in the grid test on '*The Periodic Table of Elements*'.

Tick one box

10.90	7.00	6.50	1.35	0.95

Q6 Look at the following table:

Indicators	Colour Change	pH Interval
Methyl Orange	Orange-Yellow	2.1 - 4.4
Methyl Red	Red-Yellow	4.2 - 6.3
Bromothymol Blue	Yellow-Blue	6.0 - 7.6
Phenolphthalein	Colourless-Red	8.3 - 10.0

(a) Choose the best indicator for a titration of sodium hydroxide and sulphuric acid, given that sodium sulphate has a pH of 7.

(b) Choose the best indicator for a titration of sodium hydroxide and ethanoic acid, given that sodium ethanoate has a pH of 9

What do you understand ?

Write in the answers to all questions
This test designed to find out what you have understand about Acids and Alkalis.

Q1 (a) Calculate the pH of 0.01 mole per litre hydrochloric acid solution.
(b) Calculate the [H+] concentration in moles per litre for some drinking water which has a pH of 6.

Q2 (a) The [OH-] concentration in moles per litre is 0.001. What is the pH of the solution?
(b) In some pure water at 25oC, the [H+] and [OH-] are both 10-7 moles per litre. What is the pH ?

Q3 (a) Water from an underground source is found to have a pH of 4.3. What is the concentration of hydrogen ion in moles per litre?
(b) A bottle of cleaning liquid has a pH of 10. What is the [H+] and [OH-] ?

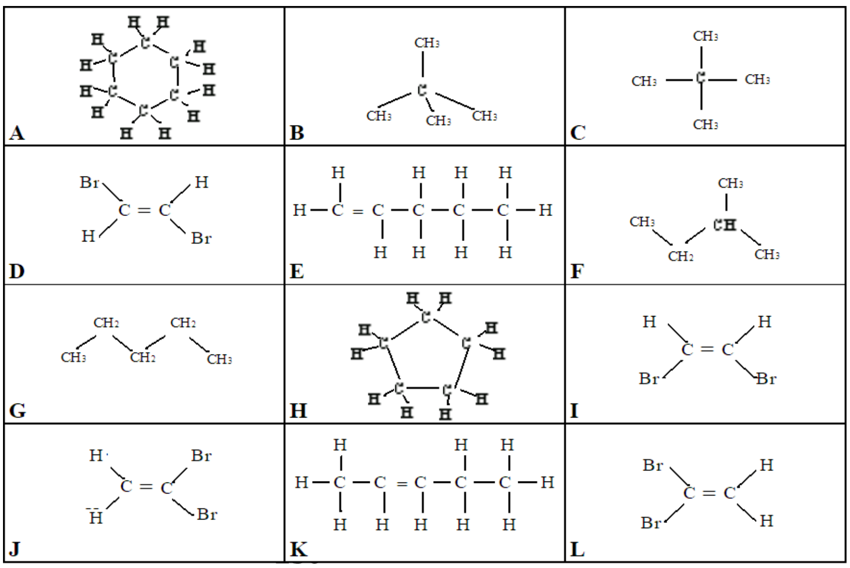
Q4 (a) Some brands of liquid soap, for use in having a shower, state that they have a pH of 5.8. Suggest why 5.8 is chosen ?
(b) The pH value of Human blood is normally 7.4 . Suppose a very ill person's blood pH is found to have fallen to 6.4.
(i) What is the hydrogen ion concentration in the blood of a *normal* person?
(ii) What is the hydrogen ion concentration in the blood of the very *ill* person?
(iii) How much *more* hydrogen ion is present in the blood of the very sick person?

Q5 You have a litre of 0.1M HCl (pH = 1) and a litre of 0.01M NaOH (pH= 12). The two solutions are mixed. What is the likely pH of the final solution. (Do not attempt any calculation

Select the box(es) which contain:

(a) Isomers of the molecule shown in box B ....
(b) Isomers of the molecule shown in box G ....
(c) Isomers of the molecule shown in box H ....
(d) Isomers of the molecule shown in box I ....
(e) Isomers of the molecule shown in box J ....

Q3 (a) Explain in three sentences why cracking so important in oil industry?
(b) "Polymerisation is the opposite of cracking"



Q2

دورية علمية محكمة نصف سنوية
5/4

The correct answer is 1, 3, 5, and 6.

(Gla… …pital of Australia but Vienna is the capital of Austria, Damascus for Syria, Paris for France and Delhi for India)

Q1 Write down the number for the answers to the following questions.

Look at the boxes below and answer the question that follow:

(Boxes may be used as many times as you wish.)

A C_2H_2	**B** C_3H_8	**C** CH_4
D C_5H_{10}	**E** C_4H_8	**F** C_7H_{16}
G C_3H_4	**H** C_7H_{14}	**I** C_6H_6

Select the box(es) which contain:

(a) Alkanes ....

(b) Alkenes ....

(c) Alkynes ....

(d) Cycloalkanes ....

(2) Balance the following equations:

$K + O_2 \longrightarrow K_2O$

$Mg + HCl \longrightarrow MgCl_2 + H_2$

$Al + O_2 \longrightarrow Al_2O_3$

$H_2S + SO_2 \longrightarrow S + H_2O$

$I_2 + Na_2S_2O_3 \longrightarrow NaI + Na_2S_4O_3$

Use these values for questions 3 and 4
Some Relative Atomic Masses
H = 1, Cl = 35.5
O = 16, N = 14, S = 32

(3) Calculate the formula mass in grams for each of:

SO2 ....

HCl ....

(4) Calculate:

(a) The mass of a mole of sulphuric acid (H2SO4)

(b) Number of moles of ammonia (NH3) in 68g of ammonia

<u>What do you understand ?</u>

This is an unusual test.

It is designed to find out what you have understood from the periodic Table of Elements.

Here is an example question:

Select all box (es) which contain names of capital cities.

1 Vienna	2 Glasgow	3 Damascus
4 Melbourne	5 Paris	6 Delhi

The correct answer is 1, 3, 5, and 6.

(Glasgow is *not* the capital of Scotland and Melbourne is *not* the capital of Australia but Vienna is the capital of Austria, Damascus for Syria, Paris for France and Delhi for India)

Q1 Write down the number for the answers to the following questions.
Look at the boxes below and answer the question that follow:

(Boxes may be used as many times as you wish.)

Q3

A K	B Ne	C Al	D Sr
E Na	F Rb	G F	H Br
I Cl	J Ca	K Ar	L Mg

Select box (es) which contain:

(a) Elements which have 1 electron in the outer shell ? ....
(b) Elements which have 2 electrons in the outer shell ? ....
(c) Elements which have 7 electrons in the outer shell ? ....
(d) Electrons where the outer shell is completely full. ....
Q4 In *one* sentence explain why a:
(a) Li atom is smaller than a Na atom?
(b) F atom is smaller than Cl atom ?.
(c) F atom is smaller than a Li atom?
Q5 In *two* sentences explain why:
A Chlorine (Cl) atom is more electronegative than a Calcium (Ca) atom

What do you understand ?
Write in the answers to all questions
You can use the Periodic Table of Elements to help you.
(1) Write the correct chemical formulae for each of the following:
Sodium Chloride ....
Calcium Bromide ....
Aluminium Oxide ....
Magnesium Fluoride ....
Carbon Dioxide ....
Copper (I) Oxide ....
Potassium Nitrate ....
Ammonium Phosphate ....
Strontium Hydroxide

(Glasgow is *not* the capital of Scotland and Melbourne is *not* the capital of Australia but Vienna is the capital of Austria, Damascus for Syria, Paris for France and Delhi for India)

Q1 Write down the number for the answers to the following questions.

Look at the boxes below and answer the question that follow:
(*Boxes may be used as many times as you wish*)

A Ne	**B** As	**C** Fe	**D** Li
E K	**F** Al	**G** Cl	**H** Ar
I F	**J** Mg	**K** Kr	**L** Na

Select the box(es) which contain elements which:

(a) Can show a valency of 2 ? ....

(b) Can show a valency of 3 ? ....

(c) Are non-metals? ....

(d) Are noble gases?
....

(e) Were known in ancient time?
....

(f) Are halogens?
....

Q2

A F > Cl > Br > I	**B** Cs > Rb > K > Na	**C** Sr > Ca > Mg > Be
D Be < Mg < Ca < Sr	**E** Li > Be> B > C	**F** Li < Be < B < C

Select the box(es) which contain elements:

(a) In a group in the right order of electronegativity ? ....

(b) In a period in the right order of electronegativity ? ....

(c) In a group in the right order of atom size ? ....

(d) In a period in the right order of atom size ? ....

Thus, the following aspects of the learning process were considered when designing the booklets:

(1) Working memory - avoiding overload .
(2) Encouraging use of relevant applications.
(3) Encouraging understanding not memorising.
(4) Linking new material to previously held material in a meaningful way.
(5) As a bonus, the aim was to make chemistry fun by the use of appropriate applications and illustrations.

The measurements were set against that background. The aim was to test to see if this new approach encouraged better understanding rather than a dependence on recall. The aim was also to assess student attitudes to see if they had become more positive towards their studies and the issues arising from them.

Some of this can be illustrated. In the first booklet (Organic chemistry) for year 11, students were offered a fun activity. This is described in using balloons to help students understand the concepts underpinning the stereochemistry around a carbon atom.

The test materials are now described and their use in assessing student performance after using the materials is described. The test materials were given the heading: “What do you Understand” and the focus was on measuring understanding rather than recall. They were designed to be as unthreatening as possible.

Four tests were designed, one for each of the four topics. The tests are shown in full below.

What do you understand ?

This is an unusual test.

It is designed to find out what you have understood from the Periodic Table of Elements.

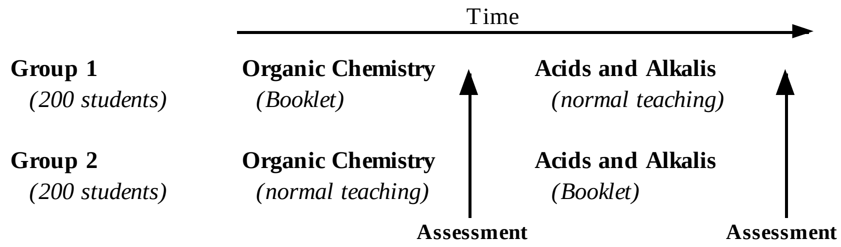
Here is an example question:

Select all box (es) which contain names of capital cities.

Vienna **A**	Glasgow **B**	Damascus **C**
Melbourne **D**	Paris **E**	Delhi **F**

The correct answer is 1, 3, 5, and 6.

Figure 7 Experimental Structure for year 11



There is one other advantage. It allows the booklet experiment to be repeated, using two age groups, although involving different topics.

The Purpose of this Experiment

The previous survey of understanding and of attitudes has shown that the students have major gaps in their understanding. They find many topics difficult and unattractive. They do not appear to be able to see the purpose, relevance and context of the work they are being asked to do. The new booklets seek to address these problems.

Previous work has shown that most of the difficulties in learning chemistry are caused by the learners being required to handle too much information at the same time. The working memory has a small and fixed capacity and it easy to overload the working memory space with highly conceptual subjects like chemistry. The booklets will aim to present the material in such a way that working memory overload is minimised. This will follow the pattern described by Danili in her work in Greece (Danili and Reid, 2004)

In a review, Reid (1999) suggested that the key to positive attitudes arising from many studies was that the material being learned was perceived by the learners as related to their current lifestyle, aspirations and interests. This led to the concept of the applications-led curriculum where the curriculum itself was designed around applications which made sense to the learners and were perceived as related to them. Examples of such curricula in physics were discussed and the very positive reactions of learners was noted. The effectiveness of such curricula in laying a sound basis for future study was also noted. The aim here is to re-structure the chemistry to be taught to make it more related to the learners. However, it has to be recognised that there are limits to this in that subject matter to be taught is laid down.

In order to make the curriculum accessible, the following teaching issues were considered: order, presentation, sequencing of ideas, applications and contexts. Very often, the aim was to start with the life examples which were likely to be meaningful and build from these. Great care was taken in, the way the material was presented so that working memory overload was minimised. This meant a step-by-step handling of some ideas.

Students are more likely to understand when they have opportunities to interact with the ideas being taught. The new teaching approach aimed to help students become active learners by providing them with material which involved discussion, considering issues, applying ideas and thinking through what was being presented to them.

of their lives. Nonetheless, they find much of the work boring and complicated. Comparisons between year groups must be treated with caution in that year 11 is a group following a science-based curriculum while the younger groups contains the whole age cohort. The observed differences are probably explainable in terms of this difference.

The New Teaching Material

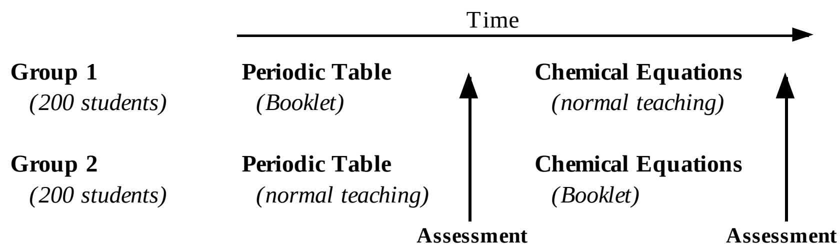
Four booklets were designed (two for year 10 and two for year 11) for use with students in the Emirates. They were designed to be used by the students in the to replace the chemistry textbooks. To develop the new teaching material, a number of factors were considered:

(a) The booklets had to cover the material required by The Emirates curriculum;
(b) They had to fit the time available in the curriculum;
(c) They should draw in useful approaches from previous research and development.

To assess the impact of the booklets in action, a total sample of 800 students was selected. There were 400 students (200 boys and 200 girls) from year 10 and 400 students (200 boys and 200 girls) from year 11. The students were aged between 16-17 years and came from a large typical secondary schools in the United Arab Emirates.

It was not possible to divide each of the samples of 400 into exactly matched groups so that the effect of the new materials could be compared to that of the teaching and learning materials currently in use. Because there were two booklets for each year group, it was possible to allow each group of 200 for each year to undertake one booklet, the other 200 acting as a control group. The experimental structure is shown in figure 6.

Figure 6Experimental Structure for year 10



In this way, group 1 is the experimental group for the teaching on the Periodic Table while group 2 is the experimental group for the teaching on Chemical Equations. This experimental structure does not require exactly balanced groups and has the ethical advantage that both groups are having the experience of the new materials in one topic.
A similar experimental structure is used for year 11 (see figure 7)
With attitudes, with year 10, as might be expected, many questions show considerable polarisation. This year group contains those who will elected to follow a science based course along with those who will opt out of sciences. The general impression left from both year groups is that here there are students who are well aware of the importance and significance of chemistry but who find the whole learning experience highly unsatisfactory. Many find it boring, difficult and are not coping too well, sometimes perhaps blaming the teacher for experiences that are not good. The data tend to confirm the need to make a curriculum closely related to context and lifestyle of learners. The data also suggest strongly that the problems faced by chemistry in the Emirates are much less serious with cognate subjects.

Students views of specific topics are highly revealing. They often see importance (or lack of it (eg lanthanides) and are aware that some topics are important in the context

Questions 1 and 2 asked for gender and school attended. **Questions 3 and 4 explored student's views of their chemistry course and their perceptions of themselves in relation to their studies in chemistry. Question 5 considered which aspects of their chemistry learning they enjoyed most while question 6 related the importance of chemistry to that of other subjects.**

Question 7 focusses on specific difficulties related to attitudes (for both years, but difficulty of chemical concept are different) while question 8 explored the influences that attract students to study chemistry in future years. Questions 9 and 10 were open questions and they aimed to discover what most and least attracts students to chemistry.

The attitudes questionnaires were given to two groups of year 10 and year 11 students. For this stage, a total sample of 225 students were involved: (115 students, 60 boys and 55 girls, for year 10, aged between 15 - 16 years and 110 students, 55 boys and 55 girls, for year 11, aged between 16 - 17 years). The questionnaires were distributed among year 10 and year 11 students in February 2003, with 10 minutes being found to be adequate time for each test inclusive of administration.

Discussing

The general impression left from the results of the two grid tests is that many students have not grasped some of the basic ideas of chemistry.

For year 10, the students have not really understood the ideas of valency, the nature of the atom, the meaning of chemical formulae and how to write them. Indeed, some are not even sure what elements are! The results leave an impression that students have memorised some things but do not really understand what it is all about. Chemistry is abstract and they have no 'feel' for the nature of chemicals.

For year 11, as might be expected, the concept of the mole is not understood. Even with this older group, valency is causing problems and again, as expected, oxidation state is an area of considerable confusion. Of greater concern is the observation that the nature of bonding and valency are poorly understood. If students have not mastered some of the basic skills, then it reduces chemistry to an abstract subject to be memorised. Perhaps it is little wonder that attitudes are not too positive.

For this stage, a total sample of 318 students was selected. There were 168 students (88 boys and 80 girls) for year 10 (aged 15-16 years) and 150 students (74 boys and 76 girls) from year 11 (aged between 16-17 years). The students came from a large typical secondary schools in the united Arab Emirates. The surveys were completed in October 2002, towards the end of the year's teaching, with 30-90 minutes being found to be an adequate time.

These grid tests aimed to test the grasp of underlying ideas in chemistry. This is the strength of structural communication grids in that they offer insights into the conceptual understanding of ideas tested.

Attitudes Questionnaire

In this exploratory study looking at problems with the learning of chemistry in The Emirates, a difficulties survey has pinpointed the key problem themes while the tests based on structural communication grids has thrown considerable light on the nature of the problems. In the next stage of this study, two short questionnaires to explore attitudes towards chemistry were used, one for year 10 and the other for year 11. Overall, it aimed to see how they related to their experiences of difficulties. Each questionnaire involved ten questions:

Question 4

An atoms is a nucleus surrounded by electrons. **A**	Atom only exist in elements. **B**	Atom are the smallest particles which can exist. **C**
Atoms have more electrons than protons. **D**	Atom are only found linked to each other. **E**	Atoms contain proton, neutrons, and electrons. **F**

Select all the box (es) which contain statements about atoms, which are true …………

Question 2

Copper **A**	Sodium phosphate **B**	Oxygen **C**
Potsaaium Cloride **D**	Magnesium **E**	Water **F**
Nitrogen **G**	Hydrogen **H**	Magnesium Oxide **I**
Aluminium **J**	Argon **K**	Ammonia **L**

Select all the box (es) which contain

(a) Elements, which can show a valency of 3 ....
(b) Elements, which can show an oxidation number of +2? ....
(c) Molecules in which there are covalent bonds? ....
(d) Molecules in which there are polar covalent bond? ....
(e) Molecules in which there are ionic bonds? ....
(f) Molecules in which there are hydrogen bonds? ....

Q3: Write in your answers:

(a) In ethane, the line between the two carbon atoms is a single bond.
What does this line represent? ....

(b) In ethene, the line between the two carbon atoms is a double bond.
What does this double line represent
...

Question 1

Mass of a mole is 18g **A**	Mole of molecules of hydrogen **B**	Mass of a mole is 1g **C**
Mass of a mole is 17g **D**	Two hydrogen atoms linked together **E**	A mole of molecules of water **F**
A mole of atoms of hydrogen **G**	2 hydrogen atoms linked to one oxygen atom **H**	A mixture of hydrogen and oxygen **I**

Select all the box (es) where there are statement which are:

(a) True about the formula: H2O? ....
(b) True about the formulas: H2? ....

Question 2

An atoms is a nucleus surrounded by electrons. **A**	Atom only exist in elements. **B**	Atom are the smallest particles which can exist. **C**
Atoms have more electrons than protons. **D**	Atom are only found linked to each other. **E**	Atoms contain proton, neutrons, and electrons. **F**

Select *all* the box (es) which contain Statements about atoms, which are true

Question 3 Look at boxes below and answer the questions, which follow:

Cu A	H_2S B	MgO C
SiO_4 D	K E	$NaBr_2$ F
AIP G	Br_2 H	Ar I

(a) Which of the following formulae should *not* exist? ....
(b) which contain formulae of elements? ....
(c) which contain formulae of compounds? ....
(d) Which are liquids at room temperature?

(e) Which are metals?

The same rubric was used at the start of the test for year 11 as that used in year 10. The actual questions are shown in figure 5.

Figure 5 Grid Test for Year 11

Question 1

(13) The *wrong* answers offered by the students reveal something of the misunderstandings and misconception; for example, if many students add a particular wrong answer, this can reveal a misconception or misunderstanding.

(14) It is possible to score it such a test and there are several ways. Here is one :

$$\text{Mark for each question} = \frac{\text{Number of correct answers selected}}{\text{Total number of correct answers}} - \frac{\text{Number of wrong answers selected}}{\text{Total number of wrong answers}}$$

(15) One grid test can be used to ask many questions, gaining useful insights into many aspects of some concept or area of interest.

(16) Clear patterns of responses can be highly informative (Reid, 2003).

Two grid tests were designed, one for year 10 and the other for year 11. The tests are now shown in full in figures 4 and 5.

Figure 4Grid Test for Year 10

<u>What do you understand?</u>

This is an unusual test.
It is designed to find out what you have understood from your previous studies.
The results from this will assist in planning future courses.

Here is an example question:
Select all box (es) which contain names of capital cities.

Vienna A	Glasgow B	Damascus C
Melbourne D	Paris E	Delhi F

The correct answer is: A, C, E, and F.
(Glasgow is not the capital of Scotland and Melbourne is not the capital of Australia but Vienna is the capital of Austria, Damascus for Syria, Paris for France and Delhi for India).

Write down the letters for the answers to the following questions.
You should select ALL the correct answers.
Look at the boxes below and answer the questions, which follow:
(Boxes may be used as many times as you wish)

It is possible to list many strengths and advantages of the SCG technique:

(1) The contents of the boxes can be words, phrases, pictures, formulae, varied, or made suitable for visual thinkers.

(2) SCG completely eliminates the guessing problems, a criticism of multiple choice questions.

(3) The analysis of the results penalises wrong answers to discourage guessing.

(4) The reasoning chain (where answers are required in an order) gives an indication of the way the student's knowledge is inter-linked.

(5) Credit in SCG is given for partial or incomplete knowledge.

(6) The student's are able to handle SCG quickly after a little practice and the time required to answer these grid question is similar or less than that required to test the same objectives conventionally.

(7) Often, there is no factually wrong information displayed in grid questions. It may be irrelevant for answering one particular question but highly relevant for anther.

(8) The grid's boxes content may be necessary to answer two or more questions, so guessing by elimination is completely ruled out.

(9) Grid questions can be designed to assess the student's degree of understanding of the topic by using a computer work station and offered as a self assessment technique which could help students identify their weaknesses and strengths.

(10) In conclusion, the flexibility of the SCG as an assessment and diagnostic tool is enormous and would lend itself to the production of much shorter and less wordy levels of complexity (Johnstone *et al*, 2000).

(11) They are much easier to set it than multiple choice questions .

(12) The c*orrect* responses offered by a student reveal something of the grasp of the fundamental concept; for example, if there are 3 correct answers but many students have missed the same one of the three, clear evidence is gained of a
developed and used by many researchers (e.g., Duncan, 1974; Johnstone & Mughol, 1979; Johnstone & MacGuire, 1987; Scottish Examination Board, 1997). A modified form of SCGs was used by the new Scottish Qualification Authority (SQA) in 1998 in its science examinations (Johnstone *et al*, 2000). The boxes are of no significance other than to hold an array of information. The number of boxes used depends on the age of the students, but 9 to 12 boxes are appropriate for students towards the end of their school studies. Any kind of information can be placed in the boxes and it is possible to ask several questions, all relating to one grid. Students have no way of knowing how many right answers are present - it could be anything from 1 to 9 with a nine box grid. It is the pattern of correct and the pattern of wrong answers which can offer insights into understanding (Ambusaidi & Johnstone, 2000).

Johnstone described different styles of objective questions as alternatives to multiple-choice. This included SCG, Venn diagrams, linked true/false statements, mind maps and logic problems (Overton, 1998).

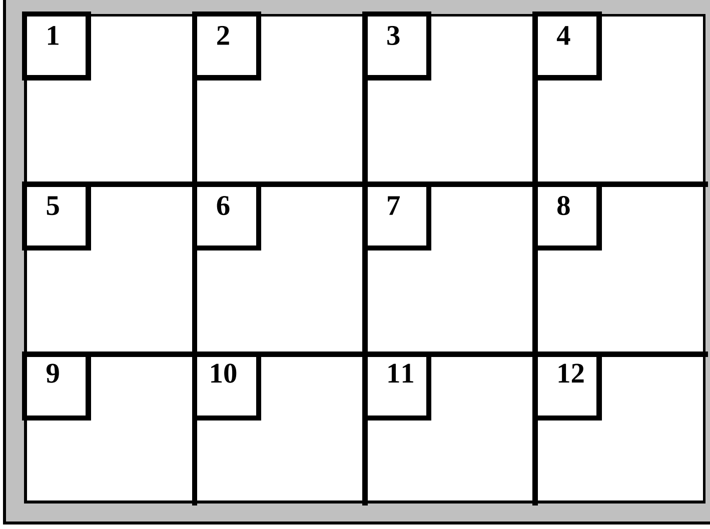
Exploring the Difficulties

In the survey described above, students were asked how they saw various topics in this studies in terms of difficulty. The approach now described looked at some of the topics which were perceived as most difficult in an attempt to gain further insights into the nature of the difficulties. Structural Communication Grids, as a diagnostic testing method, were used in this study.

The Structural Communication Grid (SCG) is an assessment technique which involves data being presented in the form of a numbered grid and students being asked to select appropriate boxes, and sometimes to put them into a logical sequence in response to a set question. It has been found that this technique gives an insight into sub-concepts and linkages between ideas held by students, so that understanding can be assessed at a deep level (Johnstone *et al*, 2000). Its introduction heralds a new resource to assist in the process of education and seems analogous to the invention of the various programmed instruction techniques (Egan, 1972).

Structural Communication Grids can be used for assessment and for diagnosis, and they provide an appropriate technique for the purpose of gaining insights into pupil difficulties in this study. Figure 3 shows the basic structure of a structural communication grid (SCG) (Johnstone *et al*, 2000).

Figure 3 : The basic structure of the SCG



The SCG idea originates from Egan's (1972) work and since then it has been

13 No chance to practice.
14 Quickly taught in order to finish the curriculum.
15 A lot of homework so too busy and can't keep the idea in mind easily and became confused.
16 Too many steps and techniques.
17 Never done it before (have no idea about it).
18 Hard to remember how to do all calculations.
19 No clear definitions were provided for differences between types of isomers.
20 I can't visually imagine.
21 Never been able to.

Students Comments on Reasons for Difficulties (year 10 and year 11)

In the free response space beside each topic, many students wrote more than one comment. These comments highlighted some of the sources of the difficulties. It is possible to group their comments under four headings, recognising that some comments do fit neatly under any one heading:

- **(a)** ***Curriculum Content.***
- ***(b)*** ***Overload of working memory space.***
- ***(c)*** ***Methods of teaching.***
- ***(d)*** ***Concept formation.***

Here are some typical comments:

1. ***The presentation of the concept in text book is not clear.***
2. ***Difficult to understand the concept.***
3. ***The concept is complex.***
4. ***There are a lot of mathematical laws.***
5. ***We studied the concept at the end of course so the teacher didn't focus on it.***
6. ***Teacher's method is bad.***
7. ***Not enough time spent to explain the concept.***
8. ***Not enough examples.***
9. ***Similar names and too many to remember.***
10. ***A lot of questions.***
11. ***The concept is difficult to relate to the questions.***
12. ***A lot of compounds.***

Topic	Easy (%)	Moderate (%)	Difficult (%)	Not Studied (%)
Mole calculation	28	20	**52**	0
Balancing chemical equations	23	23	**53**	1
Mass and volume gas calculation	40	43	13	4
Boyle's, Charles', Gay-Lussac's laws	58	24	14	4
Standard conditions	60	30	8	2
Vapour pressure	55	30	14	1
Saturated and supersaturated solutions	78	14	3	5
Molarity	58	39	2	1
Hess's law	64	18	15	3
Osmosis	61	36	1	2
Conservation of energy law	56	31	6	7
Endothermic and exothermic reactions	52	28	14	6
Enthalpy	2	6	0	92
Alkanes and alkenes	29	43	**25**	3
Homologous series	25	24	**50**	1
Alkyl groups	11	27	**51**	21
Isomerism	30	19	**50**	1
Resonance	15	60	6	19
Polymerisation	36	48	4	12
Catalyst factors	79	13	5	3
Forward and backward reaction	78	20	1	1
Dynamic equilibrium	35	40	10	15
Equilibrium law	60	38	1	1
Le Chatelier	55	31	4	10
Lewis, Arhenius, Bronsted-Lowry acids	59	20	**20**	1
Acid rain	75	20	0	5
pH and pOH calculation	22	27	**50**	1
Normal salts	38	40	12	10
Ionic product of water	26	42	**27**	5
Hydrocarbon compounds	25	46	**22**	7

Topic	Easy (%)	Moderate (%)	Difficult (%)	Not Studied (%)
Elements and compounds	81	17	2	0
Symbols of elements	79	17	4	0
Atoms and molecules	79	18	3	0
Oxidation Number	29	69	2	0
Chemical formulae	10	8	**82**	0
Atomic and molecular mass	65	35	0	0
Cathode ray	79	21	0	0
Proton, electron and neutron	83	17	0	0
Radioactivity	63	36	1	0
Alpha, beta and gamma radiation	77	23	0	0
Atomic number, mass number	86	14	0	0
Isotopes	80	20	0	0
Ground and excited state of electron	70	25	5	0
Quantum Number	13	16	**71**	0
Electron Clouds	71	29	0	0
Aufbau principle	75	25	0	0
Hund's rule and Pauli exclusion	78	21	0	1
Periodic Table	7	14	**79**	0
Halogens	72	28	0	0
Acidic and basic oxides	16	84	0	0
Lanthanides and actinides	10	19	**71**	0
Electronegativity	78	19	3	0
Type of chemical bonds	70	26	4	0
Chemical equation	13	12	**75**	0
Semi-conductors	67	30	3	0
Allotropy	86	14	0	0
Ozone	86	13	0	1
Chlorfluorocarbons	61	32	3	4
Oxy-acetylene flame	44	38	7	11
Ultrviolet rays	71	26	0	3

Year 11 Students' Responses

Table 2 shows the percentage of year 11 students' responses to each topic. As with year 10, most topics are rated as *easy*. Quite a number of topics are considered to be *moderately difficult*: Mass and Volume gas calculations, Molarity, Alkanes and Alkenes, Resonance, Polymerisation, Dynamic equilibrium, Normal salts, The ionic product of water, and Hydrocarbon compounds. Again, the real interest lies in those topics which have the highest difficulty ratings: Mole calculation, Chemical equation balance, Alkanes and Alkenes, Homologous series, Alkyl groups, and pH and pOH calculation. Enthalpy is the only topic never studied. Table 2 shows the data obtained.

Table 2 Difficulties for Year 11 Students

and Actinides, and Periodic table of elements. Oxyacetylene is the only topic never studied. Table 5.1 shows the pattern of results obtained, as percentage in each category, with the most difficult topics shaded. It is highly likely that the students would tend not to overemphasise difficulty in that they might well see this as an admission which would not prove acceptable if seen by their teachers. This is not a problem in that the data are interpreted relatively.

If their answers were *difficult*, students were invited to say why they found the topic difficult. In this way the students were given an opportunity to comment freely about the reasons for difficulties.

For this stage, a total sample of 490 students was selected. There were 240 students (127 boys and 113 girls) for year 10 (aged between 15-16 years) and 250 students (129 boys and 121 girls) for year 11 (aged between 16-17 years). The students came from a large typical secondary schools in the United Arab Emirates. The surveys were completed in May 2002, towards the end of the year's teaching, with 20-30 minutes being found to be an adequate time.

Year 10 Students' Responses

Table 1 shows the percentages of year 10 students' responses to each topic. It has to be noted that the data must be interpreted in a relative way. The purpose of the survey is merely to identify those topics which appear to be *most difficult* for the students. For the year 10 students, most topics are recorded as *easy*. Some topics are rated as *moderately difficult*: oxidation number, and acidic and basic oxides. The real interest lies in the topics which have the highest rating as *difficult*. Five topics have the highest ratings here: Chemical formulae, Chemical equation, Quantum number, Lanthanides

Easy	*''understood without difficulty''*
Moderate	*''had difficulties but I understand it now''*
Difficult	*''still do not understand it''*
Never studied	*''have never been taught this topic''*

Preparing the Survey

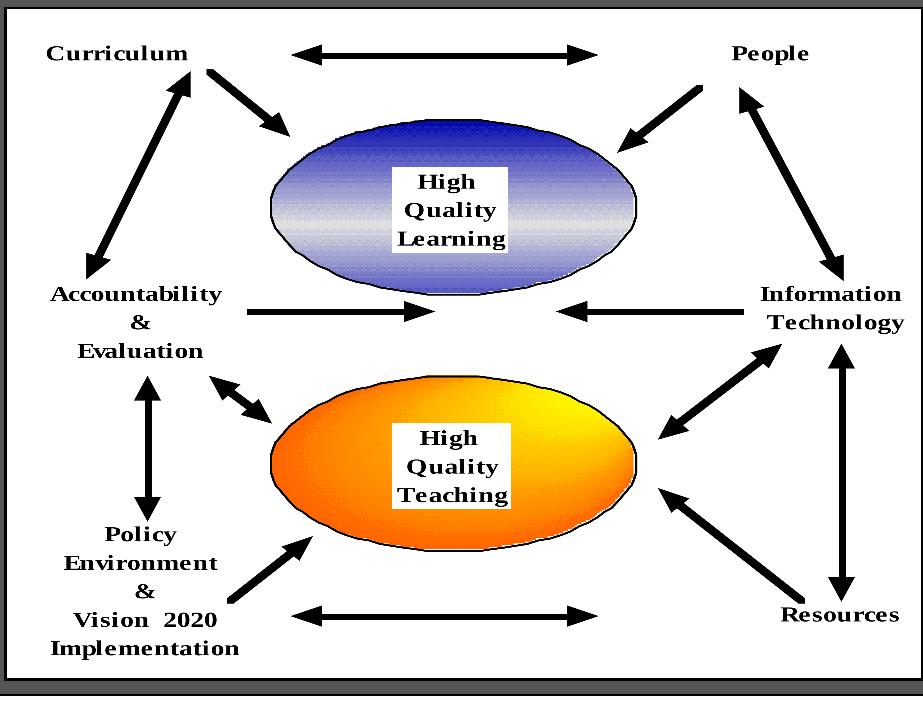
Two survey forms were developed, one for year 10 and the other for year 11. The school syllabus and textbooks were analysed to identify the main topics being covered. Thirty topics were listed in each survey and the survey forms are shown in full with the data obtained in Tables 1 and 2.

Students were asked to rate the various topics taught into one of four categories, described as: *easy*, *moderate*, *difficult* or *never studied*. Each description was defined for the students:

The Purpose of This Study

The overall aim of this study is explore the situation relating to the teaching and learning of chemistry in the secondary schools in the Emirates, to offer strategies and approaches which will reduce pupil difficulties in chemistry, these being based on the accepted understandings of psychological reasons which bring about difficulties for students. Using established models of learning and research evidence about learning in the sciences, the aim is to test some ways forward which are likely to improve the situation in the learning of chemistry in the Emirates. This testing will involve not only the investigation of student performance in chemistry tests but will also seek to explore the ways attitudes are affected by the new approaches

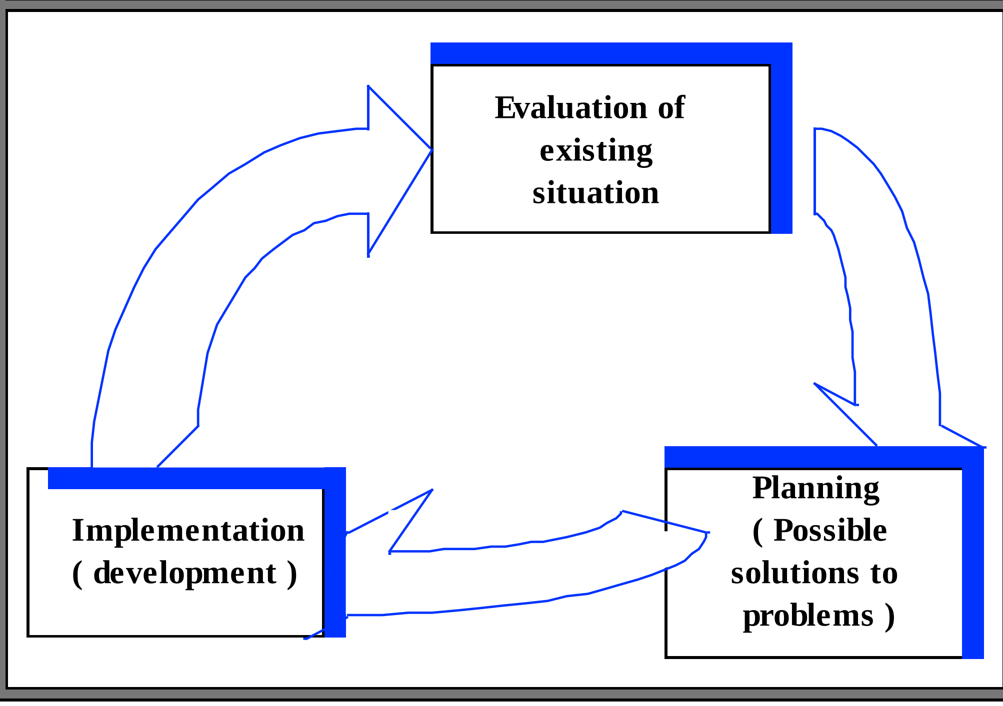
Figure 2 : *The implementation Elements Interrelationships*



(Source: Haidar, 1999).

components of vision 2020 requires a simple exposition (figure 1). *(Abdul Mawgood, 1999)*

Figure 1 : *The Components of Emirates Education Vision 2020*



Vision 2020 implementation will facilitate the achievement of the objectives of the change projects contained under each of the implementation elements. These interrelationships are illustrated as follow

The present teaching of science in Emirates tends to be isolated from its social context. As a result, it seems that some students are rejecting the study of certain science concepts especially those that contradict their values, beliefs, and conventional beliefs (Haidar, 2002).

The Specific Problems in Chemistry in the Emirates

Chemistry is mainly taught in the three stages of general education in Emirates. In both the primary and the intermediate stages, it is actually taught through teaching general science (integrated curriculum). However, at the secondary stage, it is taught separately as a major subject. Thus, chemistry only exists as a discrete discipline for the final three years at school.

The secondary stage is considered as a preparation stage where students are prepared for their roles in society as well as, where appropriate, for higher education. Chemistry, therefore, is one of the basic subjects in science curricula at the secondary stage (Haidar, 1999).

Johnstone (1991) points out that the difficulties of learning science are related to the nature of science itself and to the methods by which science to customarily taught without regard to what is known about children's learning. Haidar (1999) notes that the present science education curriculum in the Emirates ignores the social aspect of the nature of science, and science natural phenomena are not accessible in class time. Secondary students complain that they cannot see the relationship between what they study in school and everyday life.

Emirates society has a great concern about complaints from parents and teachers that a significant percentage of students do not select the science stream in the secondary school. Furthermore, low morale and low expectations for student's achievement in science among science teachers are characteristics of science teaching. There have been some complaints that the secondary school graduates are poorly equipped to do the kind of academic work required by higher education institutions in the country, arising from poor preparation of students in the sciences.

The secondary schools have science laboratories for each branch in science, but there is a little laboratory work. While most schools have libraries, their quality varies from school to another. Also, there appear to be no major effort to integrate computers in instruction (Haidar, 1999).

Emirates Education 'Vision 2020'

The vision is a comprehensive and cohesive plan for the development of education in Emirates to meet the national development requirements of the 21st century. Vision 2020 is not only a cohesive and comprehensive plan of educational development but it is also a continuous and cyclical process moving from evaluation of existing situations to planning, to implementation and then to further evaluation and so on. Each of the

The concept of attitude has played an outstanding role throughout the history of social psychology. Many early theorists virtually defined the field of social psychology as the scientific study of attitudes (Ajzen & Fishbein, 1980). Amajor issue when considering the term "attitude", is its definition and this has been used differently by various researchers (Johnstone & Reid, 1981). In thinking about learning in chemistry, attitudes towards chemistry are clearly very important. Attitudes express our evaluation of something or someone. They may be based on our knowledge, our feelings and our actions. In the context of studies in science, attitudes are evaluations, which may influence thinking and behaviour. Positive attitudes towards chemistry may well influence whether a person will choose to study chemistry as an elective subject.

Attitudes are important to us because they cannot be neatly separated from study. It is a relatively quick series of steps for a student with difficulty in a topic to move from that to a belief that they cannot succeed in that topic. They then may consider that it is beyond them totally and they, therefore, will no longer attempt to learn in that area. A bad experience has led to a perception which led to an evaluation and further learning is effectively blocked (Reid, 2003).

Previous studies have identified a number of factors generally that influence attitudes towards science. These can be broadly defined as: gender, perceived difficulty, effective teaching, students' backgrounds, and environmental factors (structural, classroom, and curriculum variables). These is no doubt that these factors plays a central role in Emirates students' attitudes towards chemistry.

There are many methods of measuring attitudes such as: Thurstone's method of equal-appearing intervals, Likert's method of summated ratings, Guttman's scalogram, and Osgood's method of semantic differential. Osgood's technique has been found to be reliable (Osgood *et al.*, 1969). Also, it has been claimed by Brunton (1961) that this technique has validity based on its higher correlation with scores obtained by the traditional methods of Thurstone, Likert, and Guttman.

Major Issues and Problems in Emirates Educational System

Various evaluation studies and sector analyses reports indicate that the Emirates educational system currently faces problems, which result in a lack of overall system efficiency and effectiveness. The major issues and problems facing the Emirates Educational system are:

(1) There is an absence of systematic and strategic planning, making any attempt piecemeal.
(2) There is an absence of clear, coherent policies to guide decision making.
(3) There is ambiguity of objectives at policy and operational levels, leading to an inability to assess accurately either whether the right things have been done or whether things have been done right.
(4) There is an irrelevant and low quality curriculum, dominated by textbook and examinations, leading to a teacher-centred classroom culture, which emphasises rote memorisation and fails to foster creativity or quality learning.

(Abdul Mawgood, 1999)

Abstract:

The difficulties of learning chemistry are related in the nature of chemistry itself and the methodes by which chemistry is customarity taught without regard to what is known about student's learning. This study initially explored secondary students' difficulties in learning chemistry in Emirates. New teaching materails were desgined to lower working memory demand and get applecation, attitudes up. Evidence from the study supports the conclusion that the curriculum of chemistry in Emirates needs redesigne.

Keywords: Exploring, Difficulties, Chemistry, Emirates.

.The fact is that many students claim that science is hard to learn (Johnstone, 1991) and they view chemistry as one of the most difficult subjects to study. Learning chemistry places demands on students and teachers that can seem insurmountable (Stiff & Wilensky, 2002). In many countries, the understanding of scientific ideas of the majority of students is thought to be very poor (Gott & Johnson, 1999). There are numerous studies in science education which have looked at school and university students' difficulties and understandings of scientific phenomena and chemistry concepts.

In the Emirates, the result of an investigation carried by Al-Marashda (2002) with secondary schools students in the department of Al-Ain Education Zone indicated major problems. In his study of difficulties in learning chemistry in secondary school in Al-Ain, he drew the conclusion that secondary students have difficulties in learning chemical concepts such as: writing chemical formula, periodic table, chemical bonds, writing chemical equation, mole and chemical calculations, liquids and solutions specialities, organic chemistry, solubility product, titration, Faraday sums, and metals. This seems to encompass almost all the curriculum - a frightening thought!