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CURRENT STATUS OF THE ADVANCED LEVEL CHEMISTRY PRACTICAL COMPONENT IN SCHOOLS OF SRI LANKA AND RELEVANT REMEDIAL CHANGES

Galhena Gamage Priyanga Sajeewanie Perera[i]
Assistant Lecturer,
Faculty of Science and Technology,
National Institute of Education,
Sri Lanka

Abstract:
Chemistry-practical in Advanced Level syllabus is not popular among students though it is a very practical subject which helps to understand the changes of the environment. Enforced demand arises year by year for chemistry as it is a main subject in science stream to enter medical and engineering faculties. In our evaluation system no attention has been given to conduct practical tests. Therefore much value has been given to theory-part than practical in teaching-learning process. As a result, students develop their memorizing power than improving their skills. In the new A/L syllabus there are 45 chemistry practical and every student has to complete at least 80% of the total list to be eligible to the final examination according to the circular. Teachers have much room to give individual attention to the students and can explain the lesson with good understanding of the weaknesses of them in practical classes. Thereby abstract concepts can be converted to concrete concepts very easily. Main objectives of this research are to investigate the participation of A/L students in chemistry practical sessions and to investigate the opinions of A/L students and teachers regarding practical sessions. To achieve this goal, a questionnaire was prepared and distributed among 30 chemistry-teachers in randomly selected five leading schools in Colombo who teach chemistry in both English and Sinhala media. Questionnaire prepared for students were distributed among 200 students who follow the science and mathematics streams of the most leading school in Sri Lanka. It was observed that the basic knowledge of the practical is not given properly before carrying out the practical. Laboratory-facilities also are not up to the standard level. Though teachers' involvement for practical in every way is very satisfactory, utilizing modern technology and new methodology to teach practical is very poor. Unfortunately more than three fourth of the students do not complete chemistry practical before the examination due to various reasons. In most cases, students don't get a chance to do the practical themselves and about 98.5% of practical

[i] Correspondence: email priyanga123perera@gmail.com

are done by teacher or laboratory assistant. The survey also revealed how the language barrier affects "local-medium" students compared to English-medium students while using modern technology such as internet/ e-mail in searching for additional knowledge. The results of the initial survey clearly explain that there is a major drawback within the whole process of teaching of chemistry practical. The laboratory-facilities even in some of leading schools in Colombo also are not up to the required level. This gives us a hint of the possible situation in rural areas. Therefore these recommendations can be extended to all the schools throughout the country to conduct chemistry practical in A/L syllabus. The request from 70% of students to "Redesign the current teaching method" emphasizes the requirement of immediate solution for this issue.

Keywords: advanced level, chemistry, practical, questionnaire

1. Introduction

1.1 Background of the study of chemistry

All the objects around us such as living things and non- living things like rocks, water and man-made substances constitute the matter of the universe. Each of particular kinds of matter, such as paper or plastic or metal each referred to as a material. Chemistry is a science of determining the composition and structure of materials and the changes that materials undergo.

Chemistry deals with all materials, is a subject of enormous breadth and difficult to exaggerate the influence of chemistry on modern science and technology. For thousands of years, human beings have changed natural materials into useful products. Modern chemistry certainly has its roots in this endeavor.

After the discovery of fire people began to notice changes in certain rocks and minerals exposed to high temperatures. For example, the ancient Phoenicians extracted a bright purple dye known as "tyrian - purple" from a species of sea snails.[1]

Chemistry has also affected the way we think of the world around us. For example, Bio-chemists and Molecular-biologists who study the molecular basis of living organisms have made remarkable findings such as structures of bio molecules and do changes regarding to the necessity.[2] When we deal with modern requirements, our local curriculum of chemistry and the practical knowledge should be revised immediately to merge with the requirements of modern world".

1.2 Advanced Level (A/L) curriculum

1.2.1 Introduction to the A/L Curriculum

In the new A/L syllabus there are 45 chemistry practical, among which 37 are compulsory. This means every student has to complete at least 80% of the total list. Most of the practical in the syllabus are related with theory. This syllabus has been designed to provide a basic background of chemistry that would be required by those intending to proceed to higher studies as well as by those who would utilize their knowledge of chemistry gained at the GCE (A/L) in various industrial applications. The syllabus comprises of 14 units presented in a sequence appropriate (but not mandatory) to be followed during teaching.

The presentation of the subject matter in each unit has been organized on the basis of competencies. The practical experiments indicated in italics at the end of subunits are essential component of the syllabus. These illustrate the link between theory and experiment.

This syllabus is the result of revising the syllabus implemented in 2017. It is effective for the G.C.E. (A/L) examination from 2019 onwards. Following changes have been made when rationalizing the previous syllabus[3].

1.2.2 Aims given in A/L curriculum (presented as units)[3]

At the end of learning of A/L syllabus students will be able to;

- understand the basic concepts of chemistry and to appreciate the unifying themes and patterns within the subject.
- develop critical and imaginative thinking in applying concepts and knowledge of chemistry to chemical phenomena.
- recognize the value of chemistry to society, and to acquire an understanding of the applications of science to technological, economic and social development.
- develop an understanding of natural resources and the issues involved in the conservation and utilization of natural resources

1.2.3 Units in the syllabus

There are 14 units in A/L chemistry syllabus.

Table 1.1: A/L curriculum

Topic Number	Title of the lesson
Unit 01	Atomic Structure
Unit 02	Structure and Bonding
Unit 03	Chemical calculations
Unit 04	Gaseous state of matter
Unit 05	Energetics
Unit 06	Chemistry of *s*, *p* and *d* block elements
Unit 07	Basic concepts of organic chemistry
Unit 08	Hydrocarbons and Halohydrocarbons
Unit 09	Oxygen containing organic compounds
Unit 10	Nitrogen containing organic compounds
Unit 11	Chemical kinetics
Unit 12	Equilibrium
Unit 13	Electrochemistry
Unit 14	Industrial Chemistry and Environmental Pollution

1.2.4 Assessment of the chemistry knowledge

Chemistry knowledge is mainly assessed in G.C.E (A/L) Examination at the end of two years in a summative assessment. But there is no practical test in that examination. In order to assess students before this final examination school based continuous assessments are done should be conducted by the teachers according to their wish. Finally marks of the five assessments should be sent to the Department of Examinations of Sri Lanka. But those marks are not affected to the final Evaluation marks.

The G.C.E. Advanced Level Chemistry paper consists with two papers, "Paper I" and "Paper II."

- Paper I - includes fifty multiple choice questions (M.C.Q) from theory and practical.
- Paper II - consists of three parts:
    - Structured Essay (Part A);
    - Essay (with Part B and Part C.).

1.3 Relationship between education theories and practical work

When Edgar Dale (1946) researched learning and teaching methods he found that much of what we found to be true of direct and indirect (and concrete and abstract) experience could be summarized in a pyramid or pictorial device Dale called "the cone of experience". In his book `audio visual methods in teaching'[4]

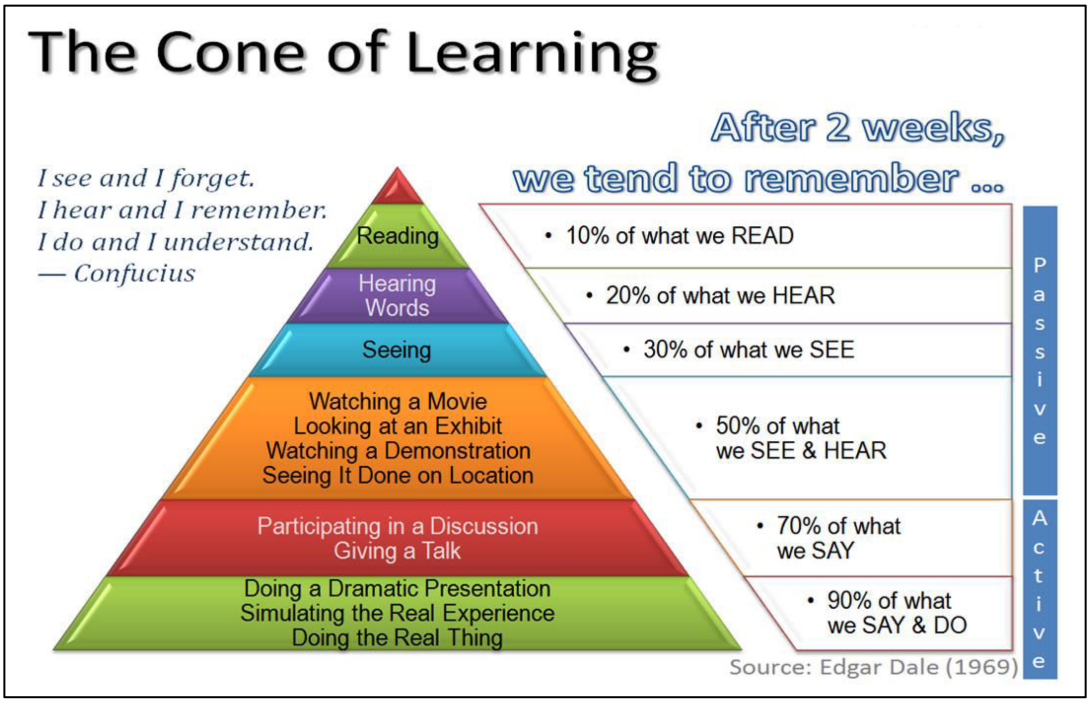


Figure 1: The cone of learning[5]

The Cone states that after two week of learning, we would remember

- 10% of the learnt if only the Reading part was there
- 20% of the learnt if only Hearing part was there
- 30% of the learnt if only Visual part was there.
- 50% of the learnt if both Audio and Visual parts were there
- 70% of the learnt if the learning was done through a discussion

- 90% of the learnt if only learning was done through active dramatic participation.

  The cone is again divided into two main sections.
  - Active Learning - here the students' active participation is there. This portion represents the bottom 2-bands of the cone. Active learning helps the student to retain the knowledge for a longer period.
  - Passive Learning - here there is no active participation of the student. He will be only a Reader, Listener or a Spectator. This portion is represented by the top 4-bands of the cone.

Dale stated that the cone is not offered as a perfect or mechanically flawless picture to be taken absolutely literally. It was merely designed as a visual aid to help explain the interrelationship of the various types of audio-visual materials, as well as their individual positions in the learning process. Dale points out that it would be a dangerous mistake to regard the bands on the cone as rigid, inflexible divisions. He said *"The cone device is a visual metaphor of learning experiences in which the various types of audio visual materials are arranged in the order of increasing abstractness as one proceeds from direct experiences."* [6,7,8]

Though all the teachers in schools and institutes are aware of this instruction, they their full attention is focused towards the theory part ignoring the practical usage of them in real life. The worst part of is, now the teachers have developed teaching and learning methods to memorize the practical in a way that the students can answer the relative questions in the examination paper even without participating any practical session.

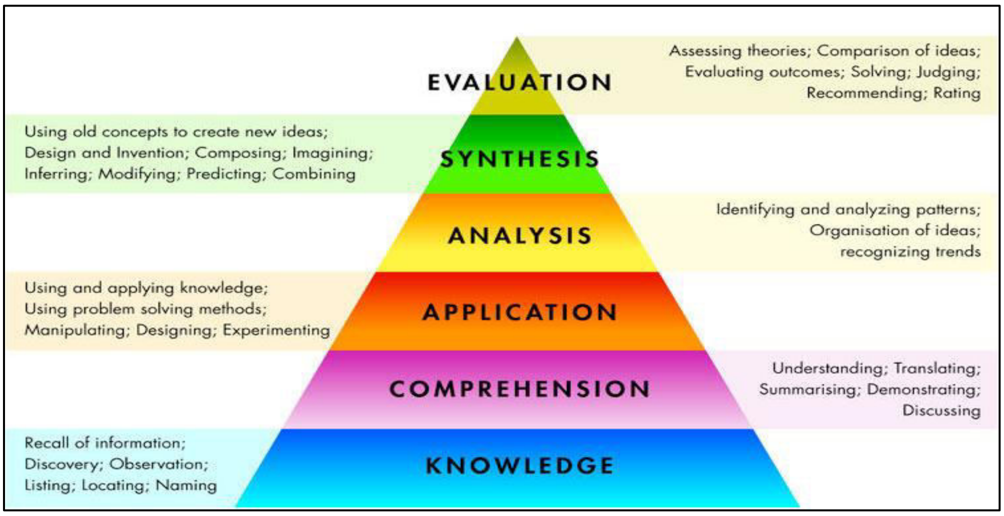


Figure 2: Bloom's Taxonomy[9]

This "Learning to Answer" trend has now completely corrupted the real purpose of the practical sessions in the syllabus. According to the Bloom's Taxonomy also can have the idea how much important doing practical in learning process.

The 3 types of Learning:[10]

- Cognitive: mental skills (*Knowledge*)

- Affective: growth in feelings or emotional areas (*Attitude or self*)
- Psychomotor: manual or physical skills (*Skills*)

A. Cognitive domain

- Knowledge: Recall data or information.
- Comprehension: Understand the meaning, translation, interpolation, and interpretation of instructions and problems. A problem is stated in one's own words.
- Application: Use a concept in a new situation or unprompted use of an abstraction, applies what was learned in the classroom into novel situations in the real situation.
- Analysis: Separates material or concepts into component parts. Its organizational structure may be understood. Distinguishes between facts and inferences.
- Synthesis: Builds a structure or pattern from diverse elements. Gather parts together to form a whole, with emphasis on creating a new meaning or a structure.
- Evaluation: Make judgments about the value of ideas or materials.

B. Affective domain

- Receiving Phenomena: Awareness, willingness to hear, selected attention.
- Responding to Phenomena: Active participation on the part of the learners. Attends and reacts to a particular phenomenon by active participation. Can emphasize, compliance in responding, willingness to respond, or satisfaction in responding (motivation).
- Valuing: The worth or value a person attaches to a particular object, phenomenon, or behavior. This ranges from simple acceptance to the more complex state of commitment. Valuing is based on the internalization of a set of specified values.
- Organization: Organizes values into priority order by contrasting different values, resolving conflicts between them, and creating an unique value system based on comparing, relating, and synthesizing values.
- Internalizing values (characterization): Has a value system that controls their behavior. The behavior is pervasive, consistent, predictable, and most importantly, characteristic of the learner. Instructional objectives are concerned with the student's general patterns of adjustment like personal, social, emotional.

C. Psychomotor domain

- Perception (awareness): The ability to use sensory cues to guide motor activity. The sensory stimulation ranges through cue selection, to translation.
- Set: Readiness to act. Includes mental, physical, and emotional sets.
- These three sets are dispositions that predetermine a person's response to different situations which are sometimes called mindsets.

- Guided Response: The early stages in learning a complex skill include imitation and trial and error. Adequacy of performance is achieved by practicing.
- Mechanism (basic proficiency): This is the intermediate stage in learning a complex skill. Learned responses have become habitual and the movements can be performed with some confidence and proficiency.
- Complex Overt Response (Expert): The skillful performance of motor acts that involve complex movement patterns. Proficiency is indicated by a quick, accurate, and highly coordinated performance, requiring a minimum of energy. This category includes performing without hesitation, and automatic performance.
- Adaptation: Skills are well developed and the individual can modify movement patterns to fit special requirements.
- Origination: Creating new movement patterns to fit a particular situation or specific problem. Learning outcomes emphasize creativity based upon highly developed skills.[9,10,11,12,13,14]

1.4 Modifying the existing practical sessions to enhance student enthusiasm

According to the theory it is obvious that carrying out practical experiments are essential for a student to understand the concepts they have learnt in theory course. But the way of presenting practical have not increased the active participation and willingness to do practical, because they cannot understand them in full. (Appendix III). In the present study of practical were redesigned and, pre-lab questions were given to test the knowledge on the theory part they have learnt in classroom. (Table 2.4) By doing this the student's knowledge and comprehension levels according to Bloom's taxonomy is assessed. Discuss answers to pre-lab questions and ask to follow practical procedure is the application level in Bloom's taxonomy. After the application collected data was analyzed. Final part of Blooms evaluation is related with the post lab questions discussion of the practical. Required calculations and conclusions are made in the practical discussion part. Teacher can evaluate the student at the discussion session.

Hence it is necessary to change the present trend and develop an enthusiasm in students and motivate them to participate in the sessions with real willingness and understanding of the broad scope of the practical.

The most challenging part here is; to get an idea of students' perspective regarding the practical sessions and to find out what type of changes they expect. (Table 2.2) Also it is important to consult A/L teachers' viewpoint on this matter as well. (Table 2.1) Bringing their suggestions and, the core structure those of practical to a same platform without degrading the real purpose of them is the ultimate goal of this project.

1.5 Objectives of the research

1) To investigate why most of the A/L students do not like to participate in chemistry practical sessions.
2) Using a survey method to investigate the A/L students and teachers opinions on practical sessions.

3) Use this understanding to develop an interest among the students and motivate them to actively participate in practical sessions.

1.6 Importance of carrying out practical

In the subject of chemistry, there are lots of abstract concepts to be learned. This subject always incorporates with practical. Therefore we can't ignore the practical part. There are some practical related parts of structured essay questions and multiple choice questions.[15] Teachers also can reach to each student and can explain with good understanding of the weakness of them. Then abstract concepts can convert to concrete concepts very easily.

2. Methodology

This research is accomplished basically in following four stages. The first two stages were categorized under phase I and the next two stages were categorized under phase II.

Table 2.1: Stages of the research

Stage 1	Analysis of the responses given by A/L chemistry teachers for the given questionnaire which was prepared with a view of finding the factors that are involved in making the new procedure to carry out the chemistry practical classes. (stage I)
Stage 2	Analysis of the answers given by A/L science students to the questionnaire to investigate the problems related with the chemistry practical classes. (stage II)
Stage 3	Redesigned the practical selected based on the data supplied by teachers and students and requested the students to carry out them as well as the ones given under the normal procedure.
Stage 4	Collect data on redesigned practical by giving questionnaire and analyzed the data. Comparison of the data for previous procedure with the proposed and making conclusions.

Phase I (Stages 1 and 2)

Questionnaire prepared for the teachers were distributed among 30 chemistry teachers of Royal College, Visaka Vidyalaya, D. S. Senanayaka College, and Ananda College. Teachers were selected randomly.

These teachers teach chemistry both in English and Sinhala media.

Above questionnaire was consist of 18 statements and teachers had to choose the response out of the following.

1) Strongly agree;
2) Fairly agree;
3) Unable to decide;
4) Fairly disagree;
5) Strongly disagree.

In addition to the above 18 questions another two questions were given to get their ideas. Suggestions given by the teachers were used when redesigning the chemistry practical.

Phase II (Stages 3 and 4)

Questionnaire prepared for students were distributed among 200 students following the biology and mathematics streams of Royal College, Colombo 07. They were chosen according to the table 2.2

There were 18 statements in the questionnaire and the students had to select one answer from the following five.

1) Strongly agree;
2) Fairly agree;
3) Unable to decide;
4) Fairly disagree;
5) Strongly disagree.

Similar to the questionnaire provided to teachers' there were two additional questions to obtain opinions of the students. Their ideas are very important to enhance the enthusiasm of carrying out chemistry practical.

Sample used for the survey is given in the table 2.2.

Table 2.2: Classes of Royal College participate to answer the questionnaire

Stream	Grade	Class	Medium
Physical science	12	M2	Sinhala
Physical science	12	M6	Sinhala
Physical science	12	ME	English
Bio science	12	S4	Sinhala
Physical science	13	M5	Sinhala
Bio science	13	S1	Sinhala
Combined class	13	MSE	English

Data collected from the above grades were analyzed in order to redesign practical. Following practical of the A/L chemistry practical guide were chosen according to student suggestions. Students' suggestions are given in.

Table 2.3: Experiments which were redesign in this project

Serial number	Practical number (Appendix)	Title of the practical
1	05	Experimental determination of the relative atomic mass of magnesium
2	17	Determination of the concentration of a ferrous ion solution using acidified potassium permanganate
3	32	Experimental Determination of the distribution coefficient for the distribution of ehanoic acid in water and butanol

Modifications of the above practical are given below. Previous Practical procedures which were chosen from the practical guide issued by NIE.[3]

2.1 Previous practical procedure

Practical no. 05
Experimental determination of the relative atomic mass of magnesium

Expected learning outcomes:
1) Determines under the room temperature and pressure, the volume of hydrogen gas liberated by a known mass of magnesium.
2) Calculates the relative atomic mass of magnesium using the amount of moles of hydrogen liberated.

Materials and equipment:
- Magnesium ribbon, 0.02.-0.04 g (about 3.5 cm);
- Burette;
- Beaker;
- Dilute hydrochloric acid, 25 cm^3;
- Water.

Instructions:
- Take a piece of magnesium ribbon about 3.5 cm long and clean with a sand paper. Weigh it accurately. Add 25 cm3 of dilute hydrochloric acid to a burette and then fill it completely with water by adding water slowly along the side of the burette. Cover the piece of magnesium loosely with cotton wool, make it into a lump and trap at the upper end of the burette.
- Nearly half fill a 250 cm3 beaker with water. Close the upper end of the burette with
- the thumb, quickly turn it upside down and dip the mouth in the water in the beaker. Clamp the burette vertically. Before gas bubbles rise up, open the stopcock of the burette quickly and bring the liquid level to the final mark of the burette. Close the stopcock and take this as the initial liquid level. When all the magnesium has reacted, take the final liquid level in the burette. The volume of hydrogen liberated is given by the difference between these two levels.

Notes:
- Under the room temperature and pressure under which the experiment was carried out, calculate the amount of moles of hydrogen gas liberated by the mass of magnesium used.
- Through relevant computation, find the relative atomic mass of magnesium.
- Discuss the errors of the experiment, the ways of minimizing them and assumptions made in the calculation.

2.2 Redesigned practical model

Practical No. 05 (No. 06 in new list)

Experiment 6: Experimental determination of relative atomic mass of magnesium using molar volume of hydrogen gas.

Aim:
To provide application of Ideal gas law and Dalton's law of partial pressures in determination of relative atomic weight of metals.

Prelab questions:

1) List different gasses that are not reacting with water;
2) List metals that react fast with dilute acids and write balanced chemical equations;
3) State Ideal gas law and Dalton's law of partial pressures. Define all terms;
4) List different techniques that can be used to collect gasses in laboratories.

Introduction:
For chemical reactions involving gases, gas volume measurements provide a convenient means of determining stoichiometric relationships. Hydrogen gas is evolved when certain metals are reacting with acids. In this experiment, amount of hydrogen gas produced in reaction of magnesium with dil. HCl acid is used to calculate the relative atomic mass of magnesium.

$$\mathbf{Mg\ (s) + 2HCl\ (aq) \rightarrow MgCl_2\ (aq) + H_2\ (g)}$$

Hydrogen gas evolved in this reaction is collected in a long, thin graduated glass tube, using an eudiometer or using a burette, by displacement of a liquid, usually water. When the magnesium reacts with the acid, the evolved hydrogen gas is collected by water displacement and its volume is measured. The temperature of the gas is taken to be the same as the temperature of the water it is in contact with because, given a sufficient amount of time, the two will reach thermal equilibrium. The level of water in the eudiometer is adjusted so that it is equal to the level of water outside the eudiometer. This insures that the pressure in the eudiometer is equal to the prevailing atmospheric pressure. Because the hydrogen gas was collected above water, and water has a significant vapor pressure, to get the pressure of pure hydrogen (dry hydrogen), we must subtract the vapor pressure of water.

The pressure of the dry hydrogen gas (P_{H2}) is calculated from Dalton's Law of Partial Pressures:

$$\mathbf{Ptotal = PH_2 + PH_2O}$$

so

P_{H_2} = Ptotal - P_{H_2O}

where P_{total} (the pressure in the eudiometer) is atmospheric pressure, and P_{H2O} (the water vapor pressure) is the pressure exerted by water vapor that has evaporated into the eudiometer. We will get the vapor pressure of water from the table below of vapor pressure vs. temperature.

Table 6.1: Temperature and Vapour Pressure

20	17.5	29	30.0
21	18.7	30	31.8
22	19.8	40	55.3
23	21.1	50	92.5
24	22.4	60	149.4
25	23.8	70	233.7
26	25.2	80	355.1
27	26.7	90	525.8
28	28.3	100	760.0

Since volume (V) of Hydrogen gas is known, the number of moles of hydrogen gas collected (n) can then be calculated from the ideal gas law:

$$\boldsymbol{n = \frac{PV}{RT}}$$ (Use P_{H2} here, not P_{total} and R = 8.314 J K^{-1} mol^{-1})

Since stoichiometry between Mg and H_2 gas is 1:1, and then we can calculate the amount of Mg in moles reacted with HCl. The mass of magnesium strip that reacted is known, therefore, we can calculate the relative atomic mass of magnesium as follows.

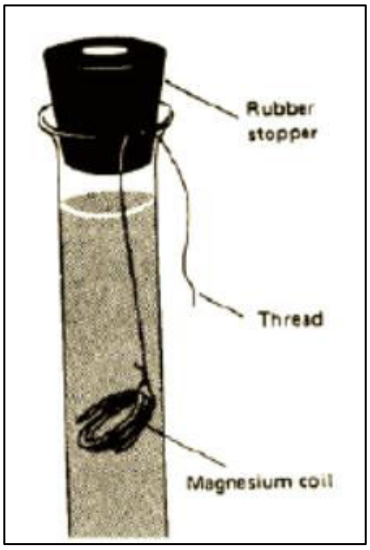
$$\text{relative atomic mass of Mg} = \frac{\text{mass of Mg strip (g)}}{\text{moles of Mg (mol)}}$$

Equipment, items and chemicals required:

Equipment and Items	**Chemicals**
Eudiometer/burette	Magnesium strips
1L beaker	A Piece of Cu wire
Burette clamps	2 M HCl
Burette Stands	
Thermometer	
Barometer	

Experimental setup

Hydrogen gas is collected by displacement of water in the following experimental set up. A burette in upside down position can also be used in place of eudiometer.



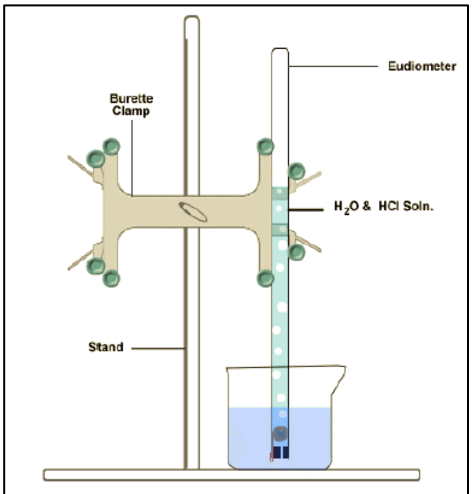


Figure 3. Inverted eudiometer illustrating gas collection and water displacement.

Figure 6.1: Experimental setup

Precautions:
Wear gloves when handling acids.

Procedure:
- 5 cm^3 of 2 $moldm^{-3}$ HCl were poured into the bottom of a 10 cm^3 graduated cylinder.
- Pour water gently on top of the HCl carefully so not to mix the HCl and added so that the cylinder was completely filled with liquid.
- A one cm strip of magnesium (~ 0.05g) was affixed to the tapered end of a cork with a hole in it and this cork was placed on top of the graduated cylinder.
- The cylinder was quickly inverted and the end placed under water in a 1L beaker filled with water.
- The reaction was initiated by the diffusion of the HCl to the metal and gas was captured in the inverted cylinder. When the reaction ceased, the levels of water in the cylinder and beaker were equalized and the volume of gas measured. The experiment was repeated three times.

Results:

Table 6.2: Experimental results

Volume of H_2 gas produced (cm^3)				
Temperature (^oC)				
Partial pressure of H_2O (torr)				

Calculations:

a) Calculate pressure of dry H_2 (PH_2) by subtracting the vapor pressure of water from the total pressure,

$Ptotal = PH_2 + PH_2O$

$PH_2 = Ptotal - PH_2O$

where P_{total} (the pressure in the eudiometer) is atmospheric pressure, and P_{H2O} (the water vapor pressure) is the pressure exerted by water vapor that has evaporated into the eudiometer. Use the table provided on the last page to find the vapor pressure of water as a function of temperature.

P_{H2} = ______________________Hg mm

b) Convert this pressure from Hg mm to Nm^{-2} (760.0 Hg mm= 1.01×10^5 Nm^{-2})

PH_2 = ______________________ Nm^{-2}

c) Use the Ideal Gas Equation to calculate the number of moles (n) of H_2 that you produced in your experiment (experimental yield). Make sure to use the correct units so that they match the units in the gas constant (R).

Moles of H_2 = ______________________mol

d) Then use stoichiometry between Mg and H_2 gas to find the moles of Mg. Then calculate the relative mass of Mg (g/mol)

Relative mass of Mg = ______________________*g*/mol

Discussion:

- Discuss possible sources of errors
- Calculate the % error when compared to the literature value

Post Lab questions:

1) List different metals that can be used in this experiment by gving reasons
2) Is piece of Cu wire interferes the amount of H_2 gas produced ? Give reasons.
3) Can you use this experimental setup to calculate the % of Cu and % Zn in a piece of Brass? Explain briefly.

2.3 Previous practical procedure

Practical no. 17: Determination of the concentration of a ferrous ion solution using acidified potassium permanganate

Expected learning outcomes:
1) Experience a titration of a self-catalyst;
2) Prepared a fixed volume of Fe^{2+} ion solution using the volumetric flask;
3) Determined the concentration of Fe^{2+} ion solution using an oxidation reduction titration.

Materials and equipment:
- Ferrous Sulphate
- 0.02 M potassium permanganate solution
- 2 M sulphuric acid
- Syrapy phosphoric acid
- 100cm3 volumetric flask
- Burette
- Pipette

Instructions:
- Transfer 3.5 g of $FeSO_4$ transfer it in to a 100 cm^3 volumetric flask. Add 50 cm^3 of 2 $moldm^{-3}$ H_2SO_4 acid in small quantities while swirling until all salts are completely dissolved. Then add distilled water up to the 100 cm^3 mark of the volumetric flask and mix evenly.
- Transfer 25.00 cm^3 of Fe^{2+} ion solution in to a titration flask. Add 25 cm^3 of 2 $moldm^{-3}$ H_2SO_4 acid and 5cm^3 of conc. H_3PO_4 acid.
- Titrate the Fe^{2+} ions in the titration flask against $KMnO_4$ solution in the burette until colour of the solution in the titration flask turn to a pink colour which is stable for more than 30 seconds. Record the burette reading at this point.

2.4 Redesigned practical model

Practical no. 17 (No. 19 in new list)
Experiment 19: Determination of the concentration of a ferrous ion solution using acidified potassium permanganate

Aims:
To provide necessary knowledge
1) on self-indicator titration
2) to prepare a given volume of Fe^{2+} ion solution using a volumetric flask
3) to determine the concentration of Fe^{2+} ion solution using redox titration

Pre lab questions:

1) What is the colour of Fe^{3+} ions and Fe^{2+} ions in aqueous medium?
2) Explain how to prepare 250 cm^3 of a 0.02 mol dm^{-3} $KMnO_4$ solution in the laboratory.

Introduction:

When colored compounds are involved in redox titrations, the titrand and titrant or one of the species may act as the indicator to obtain the end point of the titration. The reactions involved titrating Fe^{2+} ions against MnO_4- ion solution are given below.

$$\mathbf{MnO_4^- (aq) + 8H^+ (aq) + 5e \rightarrow Mn^{2+} (aq) + 4\ H_2O(\mathit{l})}$$

$$\mathbf{Fe^{2+} (aq) \rightarrow Fe^{3+} (aq) + e}$$

At the end point all Fe^{2+} ions in the solutions are oxidized to Fe^{3+} ions. Hence, further addition of $KMnO_4$ will results in purple colouration. (In dilute solutions of $KMnO_4$ this may appear as pink colouration)

Equipment and chemicals required:

Equipment	**Chemicals**
Titration flasks	$FeSO_4$ solid (fresh pack)/ ferrous ammonium sulphate
Volumetric flask (100 cm^3)	$KMnO_4$ solution (0.02 $moldm^{-3}$)
Burette	H_2SO_4 acid (2 $moldm^{-3}$)
Pipette	Conc.H_3PO_4 acid
White porcelain tile	Distilled water

Procedure:

- Preparation of Fe^{2+} ion solution: Measure about 3.5 g of $FeSO_4$ transfer it in to a 100 cm^3 volumetric flask. Add 50 cm^3 of 2 $moldm^{-3}$ H_2SO_4 acid in small quantities while swirling until all salts are completely dissolved. Then add distilled water up to the 100 cm^3 mark of the volumetric flask and mix evenly.
- Transfer 25.00 cm^3 of Fe^{2+} ion solution in to a titration flask. Add 25 cm^3 of 2 $moldm^{-3}$ H_2SO_4 acid and 5cm^3 of conc. H_3PO_4 acid.
- Titrate the Fe^{2+} ions in the titration flask against $KMnO_4$ solution in the burette until colour of the solution in the titration flask turn to a pink colour which is stable for more than 30 seconds. Record the burette reading at this point.
- Experiment should be repeated three times until the difference between burette readings at the end points vary by less than 0.1 cm^3. Then the average reading should be taken for the calculation.

Results:

Table 19.1: Observed Results

	Trial 01	Trial 02	Trial 03	Average
Volume of $KMnO_4$ used (cm^3)				

Calculations:

(i) Write the balanced redox reaction for this titration.

……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………

(ii) Calculate the moles of $KMnO_4$ used in this titration.

……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………

(iii) Calculate the concentration of Fe^{2+} ion solution

……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
…………………………………………………………

Post lab questions:

1) How would you know the $FeSO_4$ container is a fresh pack?
2) Why dil.H_2SO_4 acid is added when preparing Fe^{2+} ion solution?
3) What is the role of conc.H_3PO_4 in this titration?
4) Discuss possible sources of errors in this experiment
5) Explain the term "self -indicator" according to this experiment.
6) How would you modify this experiment for a mixture of Fe^{2+} and Fe^{3+} ion solution to find concentration of each species?

2.5 Previous practical procedure

Practical 32: Experimental determination of the distribution coefficient for the distribution of ethanoic acid in water and butanol

Expected learning outcomes:

1) Acquires the skill of determining the concentration of ethanoic acid in butanol and water layers when ethanoic acid is in equilibrium between butanol and water.
2) Using experimental data, determines the ratio between the concentrations of ethanoic acid in water and butanol at equilibrium.

Materials and equipment:

- About 120 cm3 of butanol;
- 250 cm3 of approximately 1 mol dm-3 ethanoic acid solution;
- 250 cm3 of approximately 0.5 mol dm-3 sodium hydroxide solution;
- Five reagent bottles;
- Burettes;
- Pipettes;
- Titration flasks;
- Funnels;
- Phenolphthalein.

Instructions:

- 1 mol dm-3 ethanoic acid solution can be prepared by diluting 15 cm3of glacial acetic acid (99% w/w) to 300 cm3 with water. As indicated in the following table, mix the respective volumes of liquids / solutions separately in the five reagent bottles labeled 1-5. Use burettes to measure the volumes of liquids/ solutions.

Table 32.1: Volumes of mixing liquids

System	Butanol/cm^3	1 mol dm^{-3} ethanoic	Water/cm^3	Acid/cm^3
1	20.0	40.0	-	-
2	20.0	35.0	5.0	5.0
3	20.0	30.0	10.0	10.0
4	20.0	25.0	15.0	15.0
5	20.0	20.0	20.0	20.0

- Allow the systems to stand for 10-15 minutes to reach the equilibrium. Put the system in the first bottle to the burette (The upper layer is butanol). After the separation of the layers, run 10.00 cm3 of the aqueous layer to a titration flask and add 1 – 2 drops of phenolphthalein. Titrate this solution with the prepared sodium hydroxide solution and take readings.
- Remove the remaining portion of the aqueous layer in the burette carefully and take 10.00 cm3 of the butanol layer to a titration flask. Add about 10 of water and 1-2 drops of phenolphthalein to the flask and titrate with the sodium hydroxide solution. Take the readings and complete the following table.

Table 32.2: Readings

System	Volume of NaOH require for 10.00cm^3 of butanol layer	Volume of NaOH require for 10.00cm^3 of aqueous layer	$[CH_3COOH]_{butanol}$	$[CH_3COOH]_{aq}$	$\frac{[CH_3COOH]_{butanol}}{[CH_3COOH]_{aq}}$
1					
2					
3					
4					
5					

Using experimental data suggest a value for the distribution coefficient for the distribution of ethanoic acid between water and butanol.

2.6 Redesigned practical model

Practical No. 32 (No. 38 in new list)
Experiment 38: Experimental determination of the distribution coefficient of ethanoic acid between water and 2- butanol

Aim:
To examine the dissolution and distribution of a solute in two immiscible liquids

Pre lab questions:
- What does the "distribution coefficient" mean? Explain your answer by providing the equilibrium equation.

Introduction
As we know when two immiscible solvents A and B are placed in a beaker, they will not mix and instead form separate layers. At a constant temperature, when a solute X is added which is soluble in both solvents remains in the same molecular–form in both and does not react with either of them and the system is shaken vigorously, the solute X gets dissolved in both solvents depending on its solubility in each solvent. This nature is mainly used in solvent extraction where a crude (impure) product is obtained in an experiment. For example, the reaction would have been carried out in an aqueous solution and at the end of the reaction there may be unreacted starting materials and unwanted side-products. The aqueous solution is shaken with another immiscible solvent that does not mix with water. The immiscible solvent can be chosen such that the substances that are wanted will dissolve in it, leaving the other substance in the water layer. This procedure can be repeated by adding more of the organic solvent to the aqueous layer, shaking the solutions together, separating them and running of the solution containing the required product. In the cases when a given amount of a solute dissolves between two immiscible liquids at a given temperature, it is necessary to determine the amounts/ concentrations of the solute in both the solvents. Such a

situation is described by the partition law in which the ratio of concentrations of the solute is expressed as the equilibrium constant or the partition coefficient, K_D.

This experiment illustrates the distribution of ethanoic acid between two solvents that may be considered to be immiscible, but-1-ol and water. Solutions of the acid in the two solvents are shaken together, allowed to separate and analyzed by titrating a sample of each layer with sodium hydroxide solution.

The procedure is repeated several times, using different concentration of acid and you will then be able to see whether there is any simple relationship between the concentrations of the acid in each solvent.

Equipment and chemicals required:

Equipment	**Chemicals**
pipette (10/25 cm^3)	Butan-1-ol 150 cm^3 2 mol dm^{-3} ethanoic acid 150 cm^3 ~ 0.50 mol dm^{-3} NaOH 150 cm^3 phenolphthalein indicator
burette	
separating funnels	
reagent bottles (250 cm^3) titration flasks (250ml) beakers	
measuring cylinder (10/25ml)	

Procedure:

1. Prepare the following mixtures by measuring required volumes of ethanoic acid (CH_3COOH), butanol and distilled water into a separating funnel/ reagent bottle.

Table 38.1: Volumes of mixing

Mixture	**Butan-1-ol / cm^3**	**Ethanoic acid (CH_3COOH) / cm^3**	**Water / cm^3**	**Volume of 0.50 mol dm^{-3} NaOH / cm^3**	
				Organic layer	**Aqueous layer**
1	20	10	25		
2	20	15	20		
3	20	20	15		
4	20	25	10		
4	20	30	5		

2. Shake the mixture(s) vigorously for about 5 minutes to allow ethanoic acid to dissolve and distribute in both layers. After shaking, rest the separating funnel/reagent bottle on a experimental bench (table) and allow the layers to separate. At this stage, the top layer is butan-1-ol and the bottom layer is water.
3. Using the pipette (use a pipette filler) transfer 10 cm^3 of the upper layer (butan-1-ol) into a titration flask. Using a measuring cylinder, add about 25 cm^3 of

water to the flask, followed by 3 drops of phenolphthalein indicator. Titrate the resulting mixture against the 0.50 mol dm^{-3} NaOH solution.

4. Using a second pipette, withdraw 10 cm^3 of the aqueous layer from the bottom layer (aqueous) through the top layer and transfer into a titration flask, add 25 cm^3 of distilled water and titrate it against the 0.50 mol dm^{-3} NaOH solution as before.
5. Repeat steps 3 and 4 above with other mixtures prepared and record the results in the corresponding columns in the table.
   Note: Steps 3 and 4 can be done as follows if the pipette fillers are not available in the lab). After allowing the separation of layers in step 2 of just after vigorous shaking of the mixture in a reagent bottle, transfer the mixture into a burette and allow the layers to separate. Now from this you may withdraw the required volume of water layer (which is in the bottom) first. After the completion of titration of that aqueous layer, you may remove remaining water layer and then the samples from the organic layer can be collected and titrated.
6. Calculate the concentrations of ethanoic acid in each of the respective titrations and record the results into the table below. Estimate the ratio of $\frac{[CH_3COOH]_{butanol}}{[CH_3COOH]_{water}}$.

Table 38.2: Readings

Mixture	**$[CH_3COOH]_{butanol}$**	**$[CH_3COOH]_{water}$**	$\frac{[CH_3COOH]_{butanol}}{[CH_3COOH]_{water}}$
1			
2			
3			
4			
5			

Comment on the values obtained for $\frac{[CH_3COOH]_{butanol}}{[CH_3COOH]_{water}}$ and hence give the value for the distribution coefficient K_D for the ethanoic acid in butanol and water.

Post lab questions:

1. Why the immiscible solution has to be separated before the ethanoic acid is titrated?

Table 2.3: The questionnaire given to Students after conducting the Practicals as per the Redesigned procedure

Post Practical Evaluation Form - For the Proposed Practical Education Method

Question No	Description	Comment				
		Totally Agreed	**Agreed**	**No Difference to the current method**	**Not Agreed**	**Cannot Decide**
1	The new method helps to get a better understanding of the Theory component					
2	Scope of the practical is easier to understand as the new method gives a clear vision of it before the practical starts					
3	As the pre practical questionnaire arises some doubts and uncertainties, students are encouraged to actively participate the practical session in order to get a clear understanding.					
4	The pre-practical questionnaire helps to do practical more Accurate Easier and Faster.					
5	The new method gives students an idea of real use of those practical.					
6	The clearer understanding and the accuracy of the practical done, leads students to prepare more (near) professional level reports. This develops their real presentation skill also.					
7	As the uncertainties and doubts aroused while learning the theory part is totally resolved with this newly designed practical component, students won't have to memorize them to answer the questions in examination papers.					
7	The new method has totally reformed the practical sessions where students participate them with more enthusiasm					

Note: This survey is intended only to measure the success of the project. Please be kind enough to indicate your true feeling.

3.1 Analyzing of data

Phase 1 of the survey has been designed to collect data on true feeling and opinions of both students and teachers about the current method of chemistry practical education. Data collected through the Pre-practical questionnaire given to the students were analyzed and the results are presented in Table 3.1.2 and Figure 3.1.5, 3.1.6 ,3.1.7, 3.1.8, 3.1.9 Data collected through the Pre-practical questionnaire given to the teachers were analyzed and the results are presented in Table 3.1.1 and Figure 3.1.1,3.1.2,3.1.3,3.1.4.

A. Structuring of questions in students' pre-practical questionnaire in order to extract the true information

Questions Nos. 1,2,3,9,10,11,13,14,15,18

Statement in each of those questions has been prepared so that the Disagreement of any of them highlights the requirement of change in the current state and vice versa.

Question Nos. 4,5,6,7,8,12,16,17

Statement in each of those questions has been prepared so that the Agreement of any of them highlights the requirement of change in the current state and vice versa. Data collected from 200 students were tabulated and analyzed graphically.

B. Structuring of questions in teachers' pre-practical questionnaire in order to extract the true information

The all 18 multiple-choice questions have been designed as follows:

- The agreement for any statement emphasize that they are agreed with the students' opinion in the aligned question (in students' questionnaire) and vice-versa.

Data collected from 30 teachers were tabulated and analyzed graphically. Phase 2 of the survey has been designed to collect data on true feeling and opinions of students about the proposed method of chemistry practical education.

C. Structuring of questions in students' post-practical questionnaire in order to extract the true information regarding the proposed-method

The all 7 multiple-choice questions have been designed as follows:

- The agreement for any statement emphasize that they accepted the proposed method is more effective than the current method and vice-versa.

Data collected from 200 students were tabulated and analyzed graphically.

3.2 Summary of the results

40% of the students reluctant to participate practical sessions. 54.5% of students agreed that the content of the chemistry practical is important. Basic knowledge of the practical is not given properly before carrying out the practical. Laboratory-facilities also are not up to the standard level. Teachers' involvement for practical in every way is very good. Utilizing modern technology and new methodology to teach practical is very poor. Unfortunately around 76.5% of the students do not complete chemistry practical before the examination due to various reasons.

Opinion of most of the students was that though it is very important, quality/ standard of the pre-practical explanations are not sufficient so their willingness to do practicals is forced to go down. In most cases, students' don't get a chance to do the practicals themselves and about 98.5% of practical are done by teacher or laboratory assistant.

Both teachers and students are well aware that it is worth carrying out practicals to get through the A/L examination. Hence the enthusiasm of students should be enhanced by Proper pre-practical explanation including examples of the real life applications of the particular practical. They totally accepted that the proposed method as an effective solution for most of the drawbacks of current method.

The survey also revealed how the language barrier affects "local Medium" students compared to English-medium students while using modern technology such as internet/ e-mail for searching for additional knowledge.

3.3 Discussion

Table 3.1.1: Initial Survey results of Current Enthusiasm in Students for Practical Component of A/L Chemistry Data collected from teachers

Data from Teachers					
Question No	**Totally Agreed**	**Partially Agreed**	**Difficult to Decide**	**Partially Disagreed**	**Totally Disagreed**
1	23	3	0	4	0
2	19	9	0	2	0
3	1	4	0	25	0
4	0	23	3	3	1
5	29	1	0	0	0
6	0	2	0	1	27
7	*0*	*8*	*0*	*17*	*5*
8	17	10	0	3	0
9	10	14	6	0	0
10	0	25	5	0	0
11	28	2	0	0	0
12	30	0	0	0	0
13	2	28	0	0	0
14	0	0	0	27	3
15	1	21	0	4	4

16	30	0	0	0	0
17	2	26	0	2	0
18	0	0	0	29	1
19	Laboratory Facilities OK	Laboratory Facilities Not OK	Practical Exam Needed	Practical Exam Not Needed	
	10	20	22	8	
20	There are practicals that are difficult to understand	Standard of the current practicals is ok.			
	1	29			

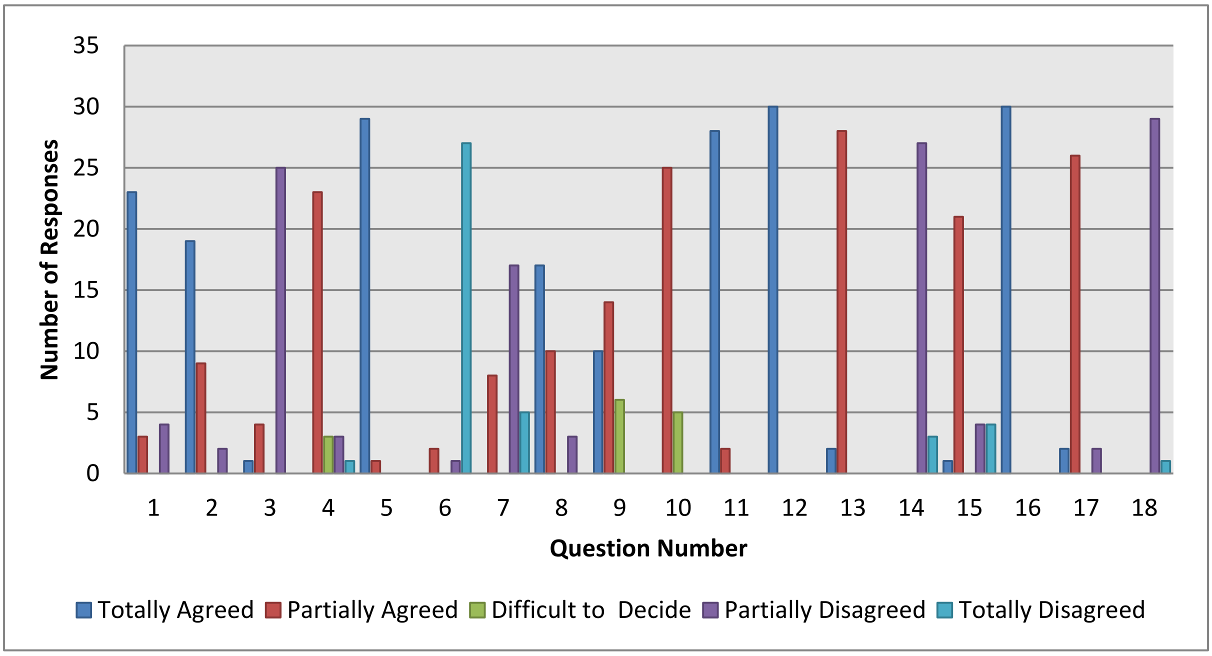


Figure 3.1.1: Graphical analysis of the teachers' comments regarding current practical education

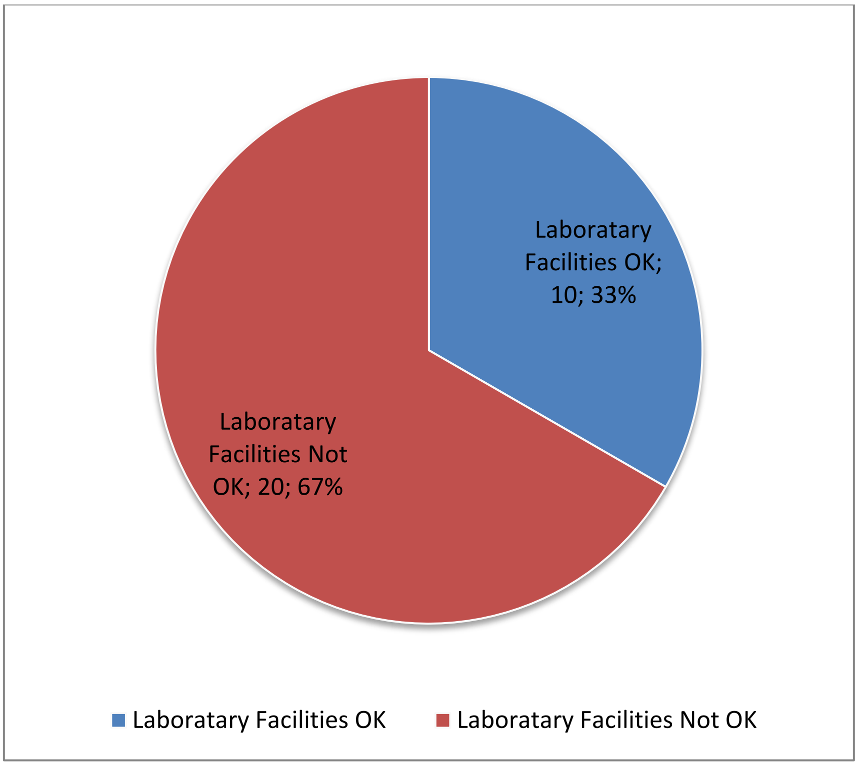


Figure 3.1.2: Analysis of teachers' opinions on current laboratory facilities

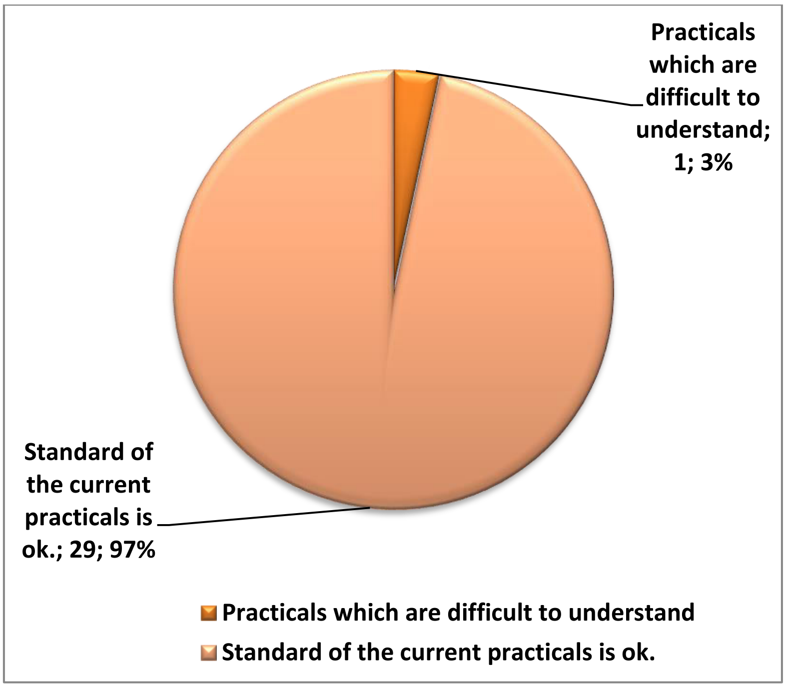


Figure 3.1.3: Analysis of teachers' opinions on the standard of practicals in current syllabus

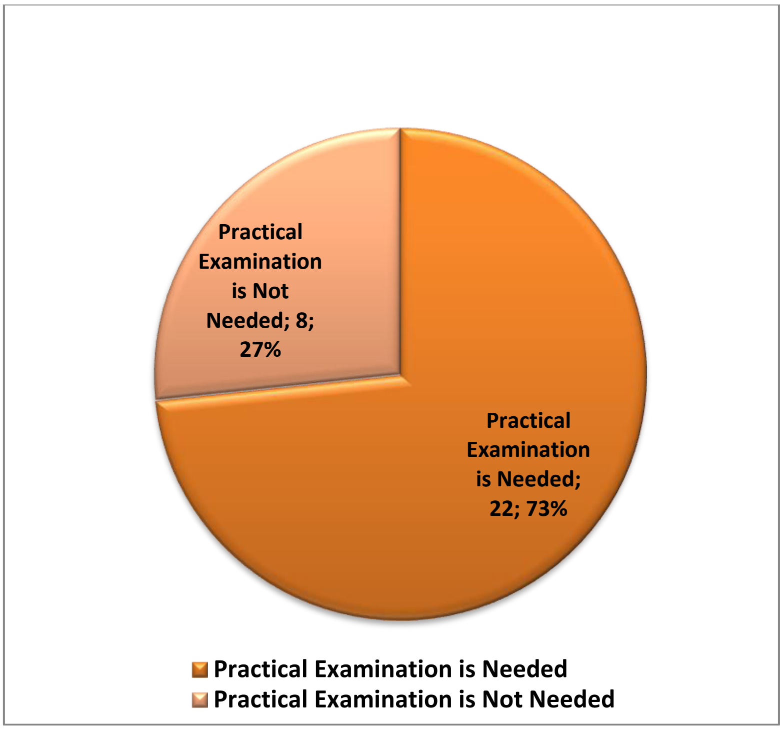


Figure 3.1.4: Analysis of teachers' suggestions on the requirement of a practical examination

Analysis of the data collected through Pre-practical questionnaire given to the Teachers:

- 76.6 % of teachers have totally agreed that the practical knowledge is more helpful to get a good result in A/L examination.
- 63.3% totally agreed that the time allocated is enough to complete the practical list (question no. 2).
- 83.3% of the teachers have accepted that most of the practical which are given in the practical list are very important (question no. 3).
- Students' low interest in doing practical is not acceptable (question no. 4)
- Most of the teachers give prior-explanation before every practical (question no. 5).
- 90% don't give short questions related to the practical and explain them with related theory (question no. 6).But students require an explanation prior to the practicals.
- According to the answers given for question no. 7 it is clear that most of the teachers give room for students to do practical themselves
- Students were put in to groups and give time to carry out practical and have their own experience (question no. 8).
- When the practical sessions are in progress, students' participation is satisfactory (question no. 9).
- Some of the teachers think it is not necessary to summarize readings on the board. Almost all the teachers totally agreed to question nos.11 and 12.
- 93.3% of the teachers think that instead of carrying out practical, student can gain the same knowledge through other sources like internet (question no. 13).

- Teachers don't feel it is difficult to explain in English than Sinhala. The participation for practical session are same regardless of the medium of teaching (question no. 14, 15).
- Whole 100% totally agreed to question no.16. More helpful material are readily available from the internet in English medium. Number of questions related to practical in A/L examination paper is fairly enough (question no. 17).
- Teachers agreed that carrying out practical have more effect when answering A/L paper.

Table 3.1.2: Initial Survey results of Current Enthusiasm in Students for Practical Component of A/L Chemistry - Data collected from students

Data from Students					
Question No	**Totally Agreed**	**Partially Agreed**	**Difficult to Decide**	**Partially Disagreed**	**Totally Disagreed**
1	51	69	35	**29**	**16**
2	69	40	55	**28**	**8**
3	41	52	58	**38**	**11**
4	**115**	**38**	4	15	28
5	**199**	**1**	0	0	0
6	**172**	**25**	1	1	1
7	**171**	**18**	8	1	2
8	**6**	**10**	12	62	110
9	18	10	38	**62**	**72**
10	55	75	10	**52**	**8**
11	85	72	38	**3**	**2**
12	**108**	**58**	18	10	6
13	10	5	48	**98**	**39**
14	121	58	18	**2**	**1**
15	188	8	2	**1**	**1**
16	**28**	**32**	52	58	30
17	**55**	**72**	38	22	13
18	0	25	22	**87**	**66**

Current Method is Satisfactory			**Current Method is Not Satisfactory**		
Totally Agreed	**Partially Agreed**	**Difficult to Decide**	**Totally Agreed**	**Partially Agreed**	**Difficult to Decide**
113	400	457	**676**	**254**	**457**

Current Method should be Redesigned	**Current Method is Good**	**Difficult to Decide**
1330	113	457

	Laboratory Facilities OK	**Laboratory Facilities Not OK**	**Teaching Effort OK**	**Teaching Effort Not OK**
19	58	142	105	95

20	**There are practicals that are difficult to understand**	**All Practicals are understandable if thought properly**	
	42	158	

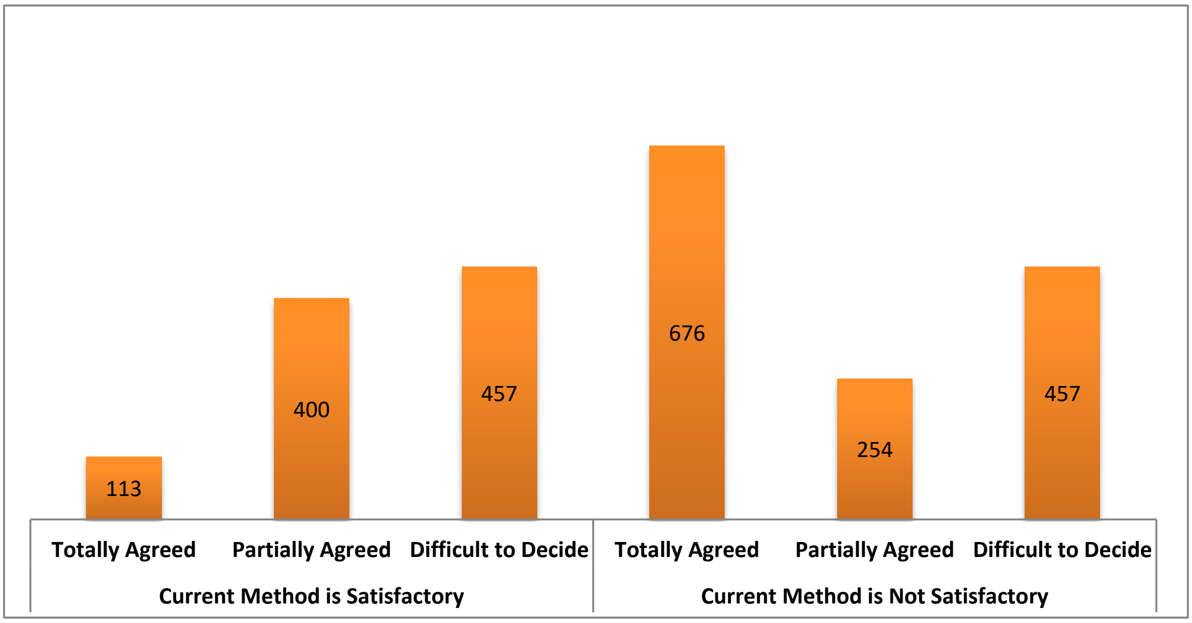


Figure 3.1.5: Graphical analysis of the data from students at initial survey

Graphical representation of the results from survey of students' opinions on current laboratory facilities is shown in figure 3.1.6

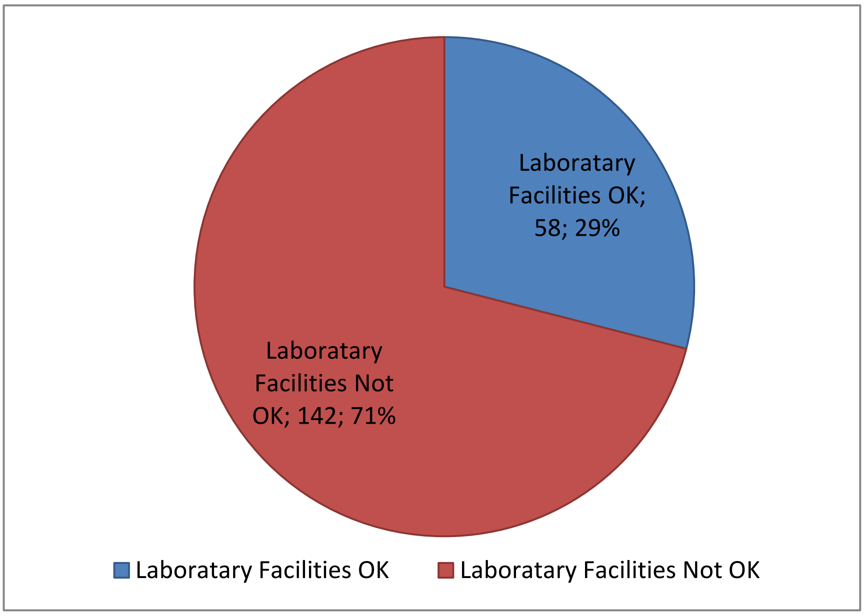


Figure 3.1.6: Analysis of opinions' on current laboratory facilities

This analysis shows that majority of students are not satisfied with the existing laboratory facilities.

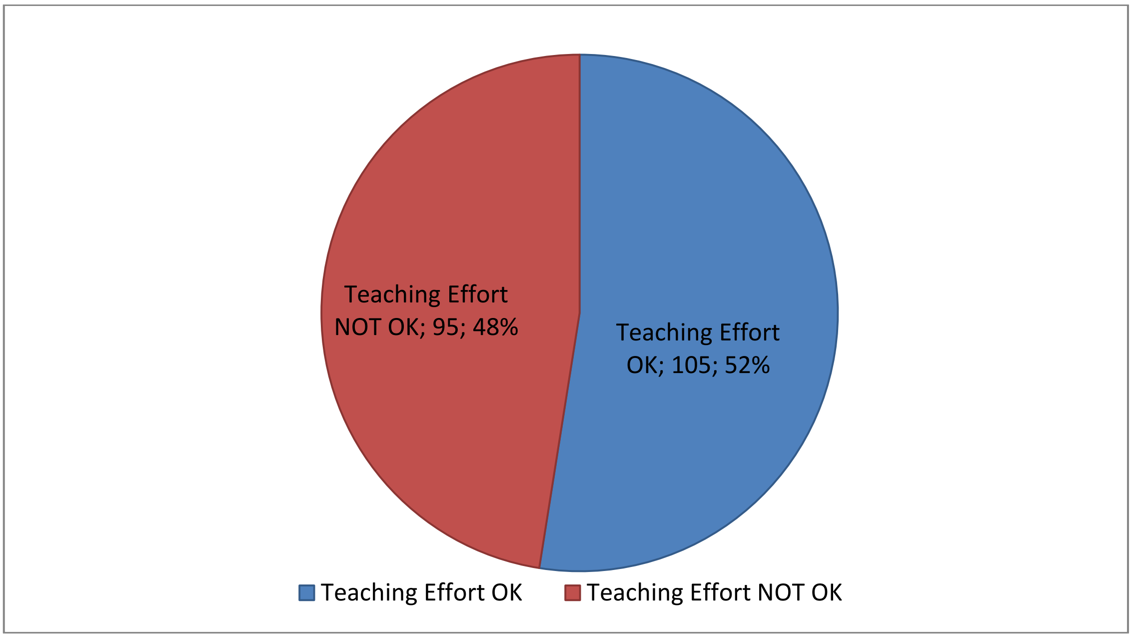


Figure 3.1.7: Analysis of current teaching efforts

Above analysis shows that the teaching effort is fairly acceptable.

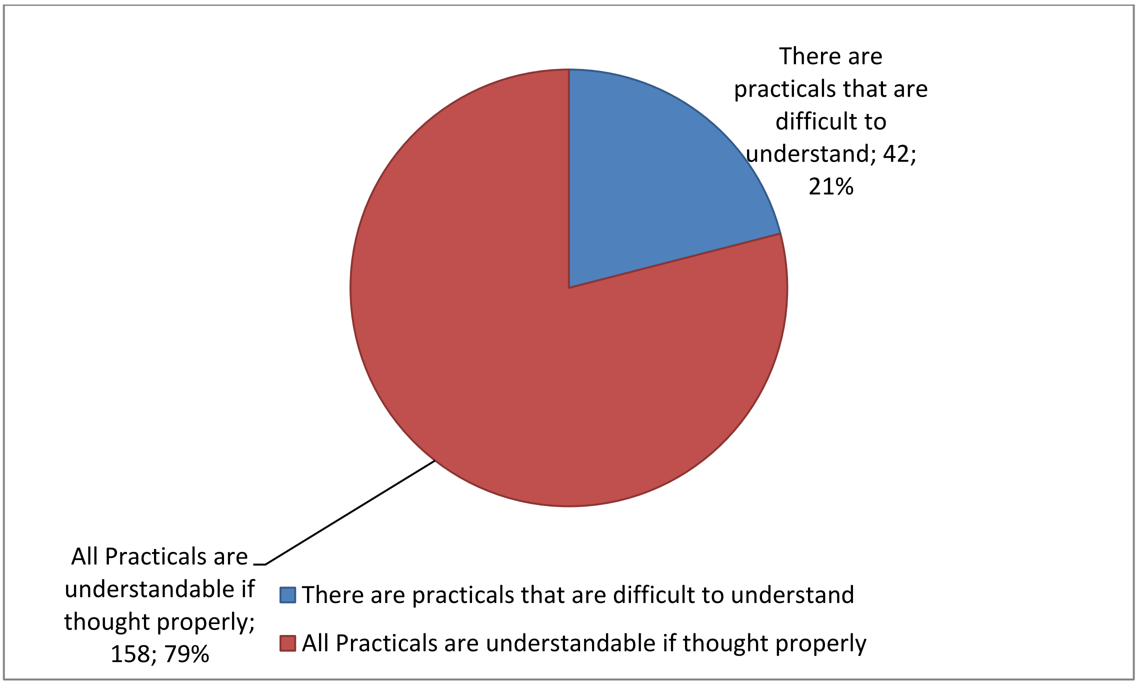


Figure 3.1.8: Analysis of students' opinions on the standard of practical in current syllabus

Analysis of students' comments on the quality of current practical procedure.

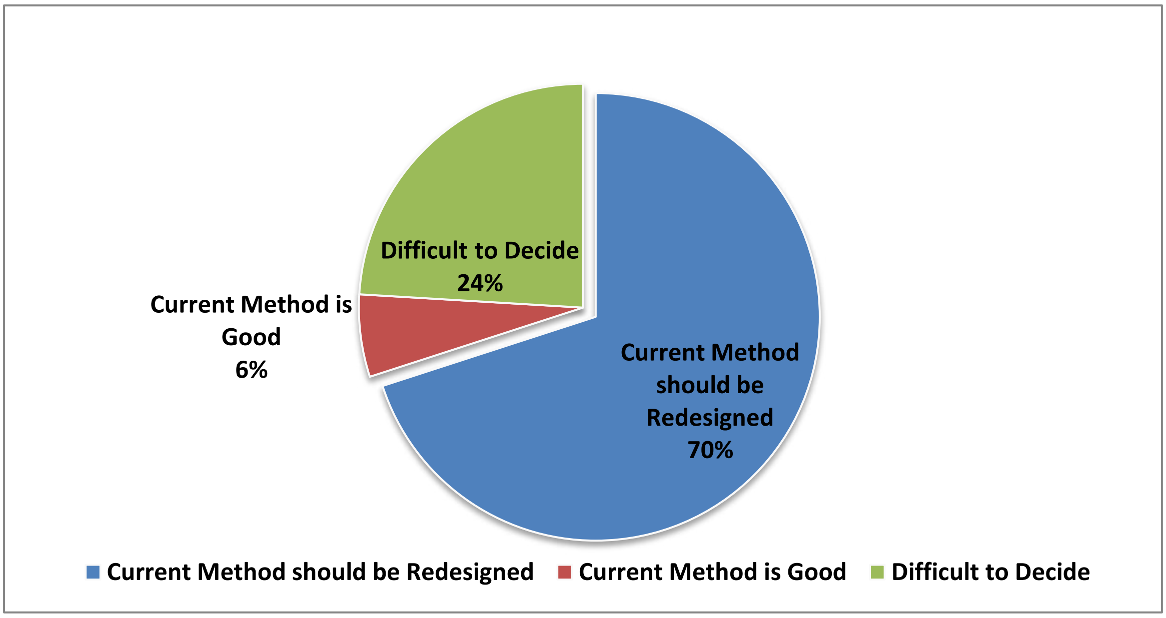


Figure 3.1.9: Summary of the initial survey results of students

3.4 Analysis of the data collected through Pre-practical questionnaire given to the Students

- It is clear from the student responses to the above questions that teachers' involvement during the practical session is in optimum level. (Question no. 10 and 11).
- High percentage of chemistry teachers guide their students to enter the practical clearly (Q- 14).
- Marking books by teachers are also in optimum level.
- 76.5% of the students do not complete chemistry practical before the examination (Q-18).

More than 50 % of students agreed that the content of the chemistry practical is important. However, most of them are reluctant to participate in practical sessions (Q-1) because;

- Basic knowledge of the practical is not given properly before carrying out the practical.
- Lab-facilities are not up to the standard level. (Q-9)
- Very low percentage of the teachers uses modern technology and new methodology to teach practical (Q- 13).

The results of the initial survey clearly explain that there is something wrong within the whole process of teaching of chemistry practical. If teachers are putting their full effort while students are well aware of the getting through the practical, there should be something that discourages those students keeping them from active participation. The request of 70% of students to "Redesign the current teaching method" gives the solution for this issue.

Considering the requirements that got revealed through the above two surveyors, a set of selected practical were re-designed.

A sample set of students were taught using this proposed method. Then a surveyor questionnaire was distributed among them in order to gather their opinions regarding the new method.

After redesigning practical procedures, a post survey (2.4)was carried out. Results are given in table 3.2.1 and figure 3.2.1

Table 3.2.1: Analysis of the Answers given by A/L Students for the Questionnaire on the proposed Method for Chemistry Practical Education

Analysis of the answers for Multiple choice questions given in the questionnaire

Question No	Totally Agreed	Agreed	No Difference to the current method	Not Agreed	Cannot Decide
1	122	58	6	4	10
2	159	22	15	2	2
3	136	54	4	0	6
4	101	62	25	5	7
5	68	42	40	15	35
6	83	65	35	8	9
7	115	44	25	6	10
Sub total	**784**	**347**	**150**	**40**	**79**

Analysis of the Comments Given by Students

The new method, when compared to current method is;

More Effective	1131
Not Different	229
Less Effective	40

The table 3.2.1 summarizes the responses given by 200 students for the "Post practical Evaluation Form". Questions in the Post-practical questionnaire were prepared in a way that;

1) Agreement ("Totally Agreed" or "Agreed") with the given statement in each question says the proposed method is more-effective than the current method. Hence they agreed that the current method should be redesigned to align with the proposed method.
2) Disagreement ("No Difference to the current method" or "Not Agreed" or "Cannot Decide") with the given statement in each question says the proposed method is less- effective than the current method.

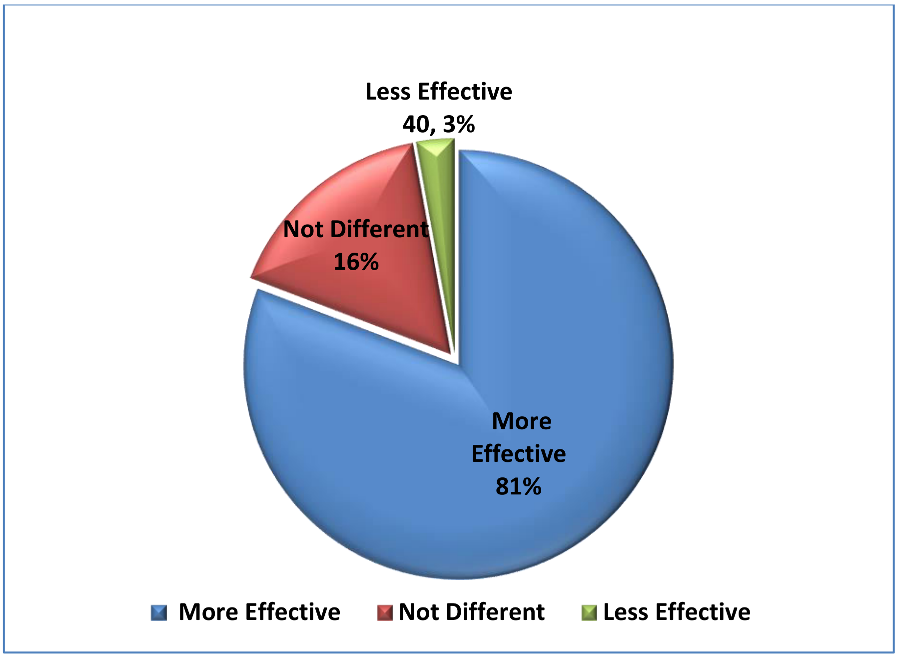


Figure 3.2.1: Comments of A/L students on effectiveness of the proposed method of procedure

4. Conclusion

This research survey was conducted in two Phases.

1) **Phase 1** was designed to identify the enthusiasm of students regarding the current teaching method of A/L Chemistry practical.
    - As per the analytical results discussed in previous chapter, it was obvious that the current teaching method is rejected by the majority of students. They wanted to carry out practical to get good results to their A/L examination.
    - Outcome of Phase-1 emphasized the necessity of change of current method.
2) **Phase 2** was designed to find out the effect of Redesigned method of practical education on students. The essence of Phase-01 was the main root of this Redesigned method. Apart from the questionnaires individual ideas of students who voluntarily participate for the project were also considered for the purpose. Most of the school teachers complain that the active participation of students for practical classes is very poor.

    According to the post-practical analytical survey, it was concluded that;
    - *The current teaching method of A/L Chemistry practical should be redesigned as per the proposed method in order to increase the active participation of students and also to achieve the target-scope of inserting those practical to the syllabus.*
    - Laboratory facilities should be increased.
    - Modern technology like Multimedia should be utilized to explain practical.

This survey reveals that the laboratory-facilities even in some of leading schools in Colombo also are not up to the level. This gives us a hint of the possible condition in rural areas. Therefore this recommendation can be extended to all the schools throughout the country while conducting chemistry practical in A/L syllabus.

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