# The Flipped Chemistry Classroom: A Case Study of Year 9 Students' Views and Performance


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# ABSTRACT

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This case study, which was conducted amongst fifteen Year 9 Chemistry students attending a co-ed state school in Malta, sought to identify how the factual topic 'Nature of Matter, Atomic Structure and Chemical Bonding' can be taught using the flipped learning technique. In addition, it aimed to establish what impact this technique would have on the students' performance with regards to the learning outcomes as specified in the chemistry MATSEC syllabus. Students' views on this approach with regards to their engagement, motivation and learning were also looked into.

Data were collected through multiple sources. These include teacher observations, students' reflective diaries, a focus group, a Likert-scale questionnaire as well as an end-of-topic test. The research findings indicate that the students managed to reach most of the outcomes specified by the MATSEC syllabus. In addition, even though most of the students were found to be very teacher-dependent, the majority of them declared that they liked this new approach. This is because they felt more prepared when attending class, they were allowed to learn at their own pace and they also found the technological aspect of it enjoyable. The flipped learning technique also freed-up class time so that more student-centred activities such as peer tutoring and collaborative work could take place. In addition, more time was spent in the identification and addressing of misconceptions, on formative assessment tasks and in providing feedback. Student support was also provided at all times.

**Supervisor** **M.Ed in Science Education**

**Dr. J. Farrugia** **May 2019**

**FLIPPED LEARNING** **ACTIVE LEARNING** **SELF-DIRECTED LEARNING**

# Author’s Declaration

I declare that this dissertation is an authentic study carried out by the author, that no part of it has been published elsewhere and that it is being presented in part fulfilment of the requirements for the degree of Master in Science Education to the University of Malta.

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Graziella Schembri

May 2019

To Martin,

who has always managed

to flip my frown

upside down

from day one.

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Graziella Schembri

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# List of Abbreviations

| | |
|---|---|
| Matriculation and Secondary Education Certificate | MATSEC |
| Bound Optimally Ordered Knowledge | BOOK |
| Flipped Learning Global Initiative | FLGI |
| Secondary Education Certificate | SEC |
| Malta Communications Authority | MCA |
| Relative Atomic Mass | RAM |
| Future Time Perspective | FTP |
| National Curriculum Framework | NCF |
| Zone of Proximal Development | ZPD |
| Learning Outcome Frameworks | LOFs |
| Professional Development | PD |
| National Statistics Office | NSO |

# Chapter 1

# INTRODUCTION

# Chapter 1: Introduction

## 1.1 Introduction

"Malta is facing a skills crisis whereby jobs are being created but then there are not enough skills to match this demand, while in certain cases jobseekers do not have the necessary work ethic to meet standards" (Bartolo, 2014, as cited in Mizzi, 2014, para. 5). This is what the Education and Employment Minister Evarist Bartolo declared back in 2014 during a seminar regarding youth unemployment. Due to this worrying situation, that same year a 'Framework for the Education Strategy for 2014-2024' was set up. It states that

> our children need to be prepared for present and future jobs, and obtain more transferable skills to avoid skill obsolescence. [This is because] it is estimated that by 2020, nearly 36% of all jobs in the European Union will require high skills, the ability to be innovative, and to adapt to new contexts (Ministry for Education and Employment, 2014, p. 5-6).

The mismatch between the skills Maltese people currently have and the skills needed by the employers in the labour market has even been noted by the European Commission where in a document issued in 2018 regarding Malta it states that "skills shortages have become very pronounced" and that "over 30% of companies report skills shortages, a significantly higher share than previous years" (European Commission, 2018, p. 2).

## 1.2 Motivation behind the Study and Research Questions

As a teacher I wish to equip myself with pedagogies that will help the students not just learn chemistry, but also acquire the necessary skills that will make them competent individuals who are able to adjust to the ever-changing demands of the labour market.

Before embarking on this study, as a teacher I have constantly found myself struggling in order to strike a balance between emphasizing the chemistry concepts as outlined by the Matriculation and Secondary Education Certificate (MATSEC) syllabus and focusing on helping students acquire skills. On the one hand, I knew that after three years studying chemistry, the students were going to sit for their Secondary Education Certificate (SEC) exam and their decision on whether they would continue studying the subject further on or not depended a lot on the grade they would have obtained. On the other hand, I was well aware of the crisis within the Maltese labour market (as described in Section 1.1), which would, after all, within a few years affect the same students to whom I was teaching chemistry.

Trying to reach both targets, most of the time I ended up focusing on knowledge and understanding in the classroom and hence, encouraging the acquisition of higher order skills through tasks I gave the students to complete at home. Unfortunately, many students found these tasks difficult to complete on their own at home. However, when we used to find some time to go through them together, I used to guide them and prompt them as need be with the satisfactory result that they did achieve the desired goal. In fact, many students have ended up telling me “Chemistry is much easier with you by my side”. Up till then, I never managed to find a solution to this recurring problem, that is, until one day, I came upon a book written by two chemistry teachers, Jon Bergmann and Aaron Sams. These teachers had also experienced the frustration of “students not being able to translate content from our lectures into useful information that would allow them to complete their homework” (Bergmann & Sams, 2012, p.4).

In an attempt to solve their problem, Bergmann and Sams came up with a new approach, that is, the flipped learning technique. By utilizing this approach, they enabled the students to gain facts and knowledge outside schools through the use of lecture videos, hence freeing up class time which could be used more effectively and efficiently helping students gain higher order thinking skills. In addition, this new way of learning, helped the students take ownership of their own learning and become more self-directive, a skill which is very crucial for students after they finish formal schooling and enter the world of work.

This flipped learning technique has intrigued me so much, that I decided to put it into practice in my chemistry Year 9 class whilst tackling a very factual topic called 'Nature of Matter, Atomic Structure and Chemical Bonding'. Hence, my research questions were:

i) How can the flipped learning technique be used in order to teach the topic 'Nature of Matter, Atomic Structure and Chemical Bonding'?
ii) What is the impact of this technique on students' performance with respect to the learning outcomes as specified in the chemistry syllabus?
iii) What are the students' views on the flipped learning approach with regards to their engagement, motivation and learning?

## 1.3 Strategies and Methods employed

In order to answer the research questions, I decided to carry out a case study. In order to do so, I firstly prepared the lesson plans of how I was to approach the chemistry topic 'Nature of Matter, Atomic Structure and Chemical Bonding' using the flipped learning technique. This was followed by the preparation of a set of tasks which students could gain factual knowledge from whilst at home, and a set of activities which the students could carry out at school that would help them acquire a diverse number of skills.

Data were gathered through a number of ways. Firstly, I made classroom observations, notes of which were jotted down in a diary. Students were also asked to write down their feelings and thoughts regarding the new learning approach in their reflective journal at the end of every lesson. When all the designated lessons were completed, students were given a Likert-scale questionnaire from which a general view of their thoughts could be gained. Hence, they were invited to participate in a focus group so that they could engage in a discussion with their peers and elaborate on their thoughts and feelings with regards to this approach even deeper. Finally, students sat for an end-of-topic test such that I could determine whether students had reached the learning objectives set by the MATSEC syllabus.

## 1.4 Outline of the Dissertation

Following this introductory chapter, an in-depth view is going to be given about how students learn, the nature of chemistry and the difficulties students meet whilst learning it, as well as a description of what flipped learning is, its advantages, disadvantages and a portrayal of the experiences of other teachers and students who have made use of this technique.

Chapter 3 will then provide a detailed description of the background setting of the study, the strategies employed, the research tools used and the methods by which the data collected were analysed. Issues related to validity, reliability, triangulation and ethics will also be discussed. In the fourth chapter, the findings from this study will be presented and discussed. The last chapter will include a summary of the main findings, the study's implications, its strengths and weaknesses and recommendations for future work.

## 1.5 Conclusion

In this chapter, a brief overview of what this research is about was given. This has included the statement of the research questions and a summary of the different methodologies employed. In the next chapter, literature regarding how students learn, why students may find chemistry challenging and what the flipped learning technique entails is discussed.

# Chapter 2

# LITERATURE REVIEW

# Chapter 2: Literature Review

## 2.1 Introduction

'What is matter made up of?' 'How was the universe created?' 'How does the human mind work?' These are some of the questions that have intrigued man since the beginning of time. The inquisitive nature of humans has given rise to the generation of several questions in an attempt to understand how the world around us works. However, it was only during the last four decades that some of the questions regarding the works of the human mind could be answered, due to technological improvements (National Research Council, 2000). Nowadays, the world is bursting with research regarding the structure of the brain and its development (Blakemore & Choudhury, 2006; Sowell, Delis, Stiles & Jernigan, 2001) as well as the neural processes taking place during thinking and learning activities (Hardiman, 2001; Leamnson, 2000).

These studies have crucial impacts on education since they influence the composition of new curricula and syllabi, the development of new teaching pedagogies as well as the creation of new assessment methods. With more cognitive researchers working alongside teachers, testing and improving their theories within real school settings and amongst 21$^{st}$ century students, the story about learning will surely continue to develop in the upcoming years (National Research Council, 2000).

In this chapter, four different approaches to learning are firstly going to be introduced. In their light, the way students learn chemistry and the stumbling blocks they meet along the way will be discussed. An approach that can be used to help students overcome these difficulties, that is the flipped learning technique, is then going to be dealt with. In addition, advantages and disadvantages of this approach are going to be pinpointed. To conclude, a showcase of how different teachers used this technique within their classes will be given.

## 2.2 How do Students Learn?

### 2.2.1 The Behaviourist Approach

In the early 20$^{th}$ century, learning was viewed as a process that does not involve any conscious thought. On the contrary, it was viewed as a passive process in which pupils acquire an empirical, measurable and observable change in their behaviour (Jarvis, Holford & Griffin, 2003). Behaviourism focuses on how a change in a person's behaviour can be brought about through changes in environmental stimuli, that is, people have to be conditioned in order to respond to a particular stimulus and hence learn. This theory states that conditioning can be of two types: classical or operant.

In classical conditioning, the desired behaviour is a reflex in response to a particular stimulus as demonstrated by Ivan Pavlov. Pavlov used dogs to show that learning occurs when one correlates an unconditioned stimulus (e.g. food) that already generates a particular response (e.g. salivation) with a new conditioned stimulus (e.g. a bell) so that the latter produces the same result as before (Danahoe, 2016). In operant conditioning, a particular behaviour is achieved through a series of positive and negative reinforcements as shown by B. F. Skinner and his rat experiment. Skinner first trained rats to press a lever by rewarding them with food (positive reinforcement). Then, he taught them to press the lever since doing so would stop them from continuing to receive an electric shock (negative reinforcement) (Michael, 1975). Other behaviourists that contributed to this theory were Edward Thorndike (Nevin, 1999) and John B. Watson (Harris, 1979).

On the one hand, the behaviourist approach leads to pedagogies where students are given immediate feedback in response to their actions and where good deeds are positively reinforced. In addition, this theory encourages teachers to simplify tasks by breaking them down into smaller steps as well as to repeat instructions as need be (Chetty, 2013). However, behaviourism puts a lot of emphasis on the importance that students engage in drilling exercises, where through constant repetition and adequate reinforcement they will finally achieve the desired result. This means that more emphasis is placed on memorization and rote-learning that lead to examinations where only one answer is correct. In short, more emphasis is put on *how* a certain behaviour is brought about rather than *what* is achieved (Cuban, 1984).

### 2.2.2 The Cognitivist Approach

In response to the limitations of behaviourism, a new learning theory known as cognitivism emerged. Cognitivists view learning as a series of events which involve the processing of information that occur mostly within what the behaviourists viewed as the 'black box', that is, the human mind. Some key figures who worked in this area include Ausubel (Ausubel, 2000), Gagné (Driscoll, 2000) and Bandura (Bandura, 2001). The advancements in technology played a crucial role in the development of this theory. In fact, it is by comparing the human mind to a computer processor that cognitivists try to understand how information is inputted in our minds, stored and hence retrieved when needed (Harasim, 2012). This process usually involves three components: The sensory memory, the short-term memory and the long-term memory as shown in Figure 1:

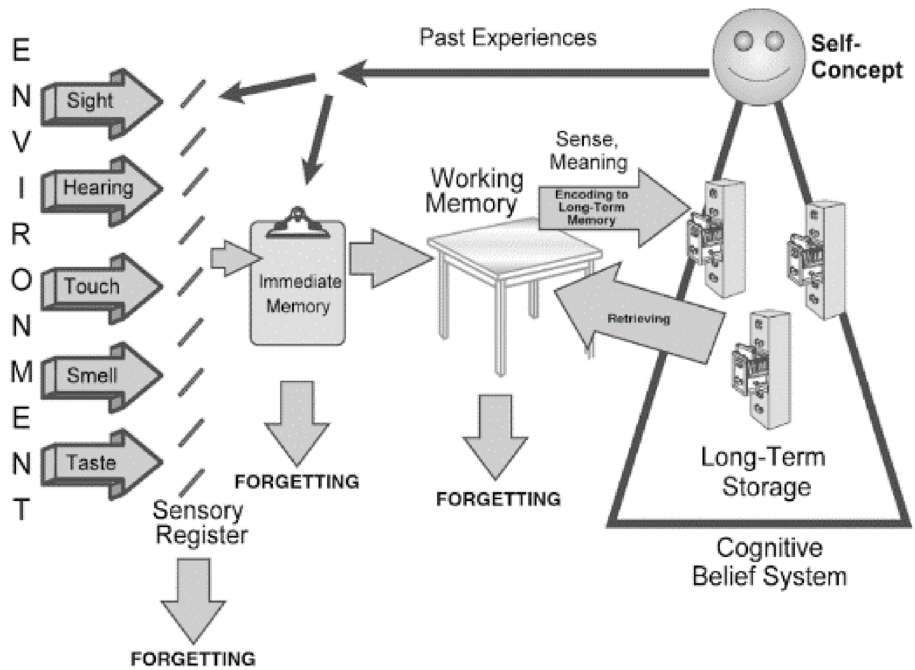


*Figure 1: The information processing model (Sousa, 2016, p.45).*

- **The Sensory Memory**

Our senses are bombarded all the time by a huge amount of information which is gathered and passed on to the brain as electrical impulses. Here, information only lasts for a short amount of time (not more than half a second for visual information and around three seconds for auditory data) unless it is transferred to the short-term memory. In order to do so, the information first passes through a sensory register/perceptual filter, so that the data that are significant are allowed to proceed to the next phase whilst other irrelevant material is forgotten (Huitt, 2003). It is important to note that information is considered as significant either if it is interesting to the individual or else if the incoming message activates a past memory or experience. This means that for teachers to catch the students' attention and motivate them to learn, they firstly need to present concepts in a way that appeal to the students as well as link new information to prior knowledge. Only by doing so, would they increase the chance that the information that is being presented to the students passes easily from the sensory memory to the short-term memory (Huitt, 2003).

- **The Short-term Memory**

The short-term memory is divided into two parts: The immediate memory and the working memory. Sensory information that succeeds in passing through the sensory register first proceeds to the immediate memory. This is the place where information lies for a short period of time (up to 30 seconds) until a conscious or a subconscious decision is taken upon whether the information is important or else can be disposed of (Sousa, 2016). In order to do this the brain processes information in a hierarchical fashion as follows:

i) **Data Affecting Survival (Reflexive):** Firstly, if any of the sensory information collected is interpreted as a threat, for example the smell of something which is on fire, a rush of adrenaline is aimed towards the brain such that the attention goes upon the origin of the stimulus.

**ii) Data Generating Emotions (Reflexive):** Sometimes students react to a situation in an emotional manner and they let feelings such as anger and fear take over their rational thought. Emotions tend to be very powerful. Some may be so strong that they cause the brain to stop any conscious thought and instead strengthen the memory of the event. This means that teachers should help students feel emotionally secure whilst in class by creating a positive environment where the students feel the teacher is there to guide them and not to punish them after spotting them doing something wrong.

**iii) Data for New Learning (Reflective):** Only after the students feel that they are physically and emotionally secure are they able to direct their attention and thoughts towards learning a subject's content (Sousa, 2016).

Those pieces of information that catch one's attention and hence require conscious thought pass from the immediate memory to the working memory. Any information that is required from the long-term memory can also be retrieved. Baddeley (2001) proposed that the working memory is made up of three parts: The Visuospatial Sketchpad, the Central Executive and the Phonological Loop as shown in Figure 2.


*Figure 2: The three parts of the working memory (Baddeley, 2001, p.852).*

The Visuospatial Sketchpad, as the name itself implies, is the space where visual information is refined while the Phonological Loop is where the auditory material is processed. However, it is the Central Executive that manages all the necessary work regarding the shaping and rebuilding of information for future storage in the long-term memory (Baddeley, 2001).

- **The Long-term Memory**

The long-term memory, unlike the sensory memory and the short-term memory is able to store an infinite amount of information including mental images, procedures, facts as well as anecdotes (Huitt, 2003). However, not all of the data present in the working-memory get encoded and stored in the long-term memory. Instead, data that are deliberated to be unnecessary are once again forgotten. As mentioned earlier, survival and emotional material are considered to be important and hence these are quickly transferred to the long-term memory. However, in classrooms where these two elements are not present, the decision upon whether certain data are kept or deleted falls on other criteria. At this point, the brain makes a connection to prior knowledge and focuses on whether the new data make sense and are relevant to the individual. If the answer to both criteria is positive, there is much more chance that the information is stored in the long-term memory for future reference (Sousa, 2016). This means that for students to learn, before introducing new concepts, teachers should always start from more familiar ones, helping students make meaningful connections between the known and the unknown.

### 2.2.3 The Constructivist Approach

The cognitivist approach to learning was eventually criticized for the fact that it does not take into consideration the active role students have in constructing knowledge. Learning was still characterised as the transmission of information from the teacher to the students with the pupils' job being that of assimilating the newly gained knowledge with prior knowledge. However, in the 1970s during an era where an educational reform was taking place in both America and Europe, the active collaboration between teachers and students in the construction of knowledge started being recognized (Ültanir, 2012). Constructivists believe

> that individuals create or construct their own new understandings or knowledge through the interactions of what they already believe and the ideas, events, and activities with which they come into contact. The teacher is a guide, facilitator, and co-explorer who encourages learners to question,

> challenge and formulate their own ideas, opinions and conclusions (Ültanir, 2012, p.195).

Constructivism is not a rigid and prescriptive theory, stating the exact way that students should learn. On the contrary, it is rather a descriptive theory, explaining the ideology behind it but at the same time allowing teachers to choose for themselves how to employ it within their classrooms (Richardson, 1997). Some of the pedagogies that can be employed by constructivist teachers include project-based learning (Barak & Dori, 2005), case-based teaching (Williams, 2005), inquiry-based learning (Wu & Hsieh, 2006), problem-based learning (Ram, 1999) and student peer teaching (Ramaswamy, Harris & Tschirner, 2001).

Jean Piaget, a French Swiss psychologist who is renowned for his establishing work regarding the cognitive constructivist approach, believed that intelligence is not simply inherited. Instead, it matures in stages according to the biological development of the individual and due to environmental stimuli s/he receives. Piaget believed that children cannot learn by simply feeding them information. On the contrary, they tend to construct their own knowledge through the use of mental representations which he called schemas. When children receive a new stimulus, they firstly compare it to their schema. If the two of them are complementary, a process of assimilation takes place where the new piece of information gets integrated with the existing one. If on the other hand there is a discrepancy between the schema and the new data, the schema has to change in order to accommodate the newly acquired material. In this way equilibrium is reached and learning takes place (Powell & Kalina, 2009).

Lev Vygotsky's view contrasts with Piaget's since he believes that the mind does not work in isolation. On the contrary, he believes that knowledge is spread amongst different people and environments and therefore, students can only build their own knowledge through the interaction with others. Vygotsky, who is well known for his social constructivist approach, explains that there are tasks which students cannot complete on their own because they are too difficult for them. However, these tasks can be mastered with the scaffolded guidance of a more knowledgeable other such as an adult or a more experienced peer. The gap between what a student can do independently and what s/he can do with help of others is better known as the Zone of Proximal Development (ZPD) (Chaiklin, 2003).

### 2.2.4 The Connectivist Approach

Behaviourism, cognitivism and constructivism, however, are learning theories that have flourished at a time when technology had no or very little influence on learning. Up till forty years ago, students used to complete their schooling with the aim of taking up a career to which they would stick to for life. It was a time where knowledge developed at a very slow rate and where it took decades to change. However, during the last twenty years things have changed. Technological improvements and modifications are occurring on a day-to-day basis and this has not only changed the way we live but also the way we learn. This means that learning theories should also continue to be developed in order to reflect the needs and reality of the present situation (Siemens, 2005).

With these thoughts in mind, Stephen Downes and George Siemens proposed the theory of connectivism, a learning theory that addresses the requisites of today's digital age. Unlike other learning theories, connectivism does not focus on what happens inside a person's brain during learning but rather on how knowledge is created within networks. It all starts when a learner connects to a learning community with which s/he interacts, shares information, communicates and discusses. Such a community, which is described as a node, in turn, forms part of an extensive network. This is made possible with the rise of technologies such as YouTube, social networks, blogs, online discussion forums and Web browsers (Kop & Hill, 2008). Therefore,

> whereas in the past learning was competitive, coercive and paternalistic, the new ethic of learning is collaborative, global and universal. It is collaborative in that learners need to work with each other. It is global in the sense that every society has a contribution to make and a responsibility to each other. And it is universal because every part of a society must invest in learning and participate (CISCO Systems, 2010, p.1).

According to this theory, learning is not a linear process but rather a "messy" and "chaotic" one (Marhan, 2006, p.215). Knowledge is present in the world around us in a chaotic manner which in Nigel Calder's words is a "cryptic form of order" (as cited in Siemens, 2005, p.6). It is therefore the students' quest to evaluate facts, determine whether a piece of information is relevant or not, build links between different pieces of data and identify patterns within a set of results in order to unveil knowledge that firstly appears to be hidden. With the connectivist approach, "the meaning of incoming information is seen through the lens of a shifting reality. While there is a right answer now, it may be wrong tomorrow due to alterations in the information climate affecting the decision" (Siemens, 2005, p.7). Metacognition is therefore considered to be a crucial skill for students in order to become autonomous learners.

In the next section, the difficulties students encounter whilst studying chemistry will be discussed in light of these four approaches of learning. By taking into consideration the literature, informed suggestions could be given on how these barriers could be overcome.

## 2.3 Learning Chemistry

According to Chiu (2005), "chemistry is a world filled with interesting phenomenon [*sic*], appealing experimental activities, and fruitful knowledge for understanding the natural and manufactured worlds. However, it is so complex" (p.1). The belief that chemistry is an intricate and difficult subject is shared amongst a large number of students globally (Childs & Sheehan, 2009; Tregust, Duit & Nieswandt, 2000; Sözbilir, 2004). This is resulting in a decline in the number of students studying chemistry and hence opting for a career in chemistry (Awan, Sarwar, Naz & Noreen, 2011; Browman, Ekborg & Johnels, 2011; Salta & Tzougraki, 2004). The perception that chemistry is a difficult subject was also found locally. In a study carried out by Baldacchino (2016), it was found that 53% of the participating students coming from secondary and post-secondary schools found chemistry hard to understand and study. In addition, 59% of the learners stated that they do not intend to continue studying chemistry at more advanced levels.

Sirhan (2007) carried out a study in an attempt to uncover the reasons as to why students find chemistry so challenging to study. He found that this was due to the five reasons discussed in Sections 2.3.1 – 2.3.5.

### 2.3.1 The Nature of Chemistry

According to Johnstone (2000), chemistry is regarded as a difficult subject by many students due to the fact that "we are trying to share our beautiful subject with young people in an apparently '*logical*' way and, at the same time conflicting with what we know about the way people learn (*'psychological'*)" (p.10). For example, taking a look at the Year 9, Chemistry Syllabus in schools in Malta, one would notice that within the first three months from when the students are first introduced to the world of chemistry, they are exposed to the kinetic theory, the elements and their symbols, atomic structure, ionic and covalent bonding, writing formulae and balancing equations (Curriculum Management and eLearning Department, 2010). Although this seems to be a very 'logical' way of organizing the basic concepts students need in order to understand how chemistry works, the truth is that "the logic is that of the expert not the learner" (Sirhan, 2007, p.6). What seems to be logical to the professional and skilled chemist may not be psychologically attainable by the novice.

Johnstone (2000) believes that chemistry consists of three levels which are usually represented pictorially in the form of a triangle, known as the 'Chemistry Triplet' as shown in Figure 3. These are:

i) the macro and tangible – what can be perceived by the senses;
ii) the sub-micro – what can be explained in terms of particles;
iii) the representational – what can be illustrated through the use of symbols, formulae, equations, stoichiometry, mathematical calculations and graphs.

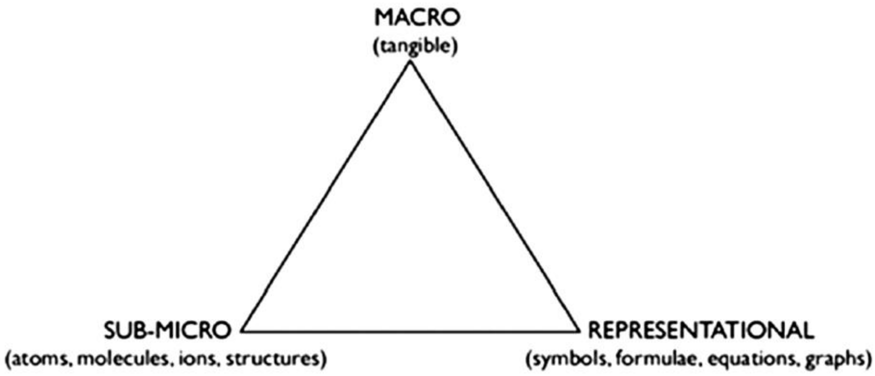


*Figure 3: The Chemistry Triplet (Boddey & de Berg, 2015, p.215)*

Each of these three levels are equally important and students are expected to pass from one level to another in order to have a good grasp of chemistry concepts. However, teachers need to be careful not to introduce all three aspects at once since "the trained chemist can keep these three in balance, but not the learner" (Johnstone, 2000, p.9). This is due to the fact that students may still be operating at Piaget's concrete operational stage even though they are asked to work out tasks that require them to be in the formal operational stage (Childs & Sheehan, 2009). Such an action would only result in an overload of the students' working memory. In addition, when students try to deal with these three facets of one particular concept at once, they are unlikely to find a connection to what lies in their long term memory. This will result in the manipulation of information into a more concrete form, giving rise to misconceptions (Johnstone, 2000). For example:

> A teacher is trying to show that gases expand on heating and tries to introduce a kinetic picture and even some simple maths. The student remembers that things in general expand on heating, ignores the kinetics and rationalises the experiment by assuming that the atoms have expanded! (Johnstone, 2000, p.11).

## 2.3.2 Working Memory Space Overload

As discussed in Section 2.2.2, the working memory is a space where the visual and auditory information that is received from the immediate memory is processed and transformed in order to be stored in the long-term memory for future use

(Baddeley, 2001). The working memory has a definite size and the average adult is able to hold seven ‘chunks’, that is, units of information at one go. When faced with a task that requires the learner to hold several pieces of information at the same time, thereby exceeding the capacity of his/her working memory, the performance of that particular individual will diminish due to overloading (Johnstone & Kellett, 1980). This is shown in Figure 4.

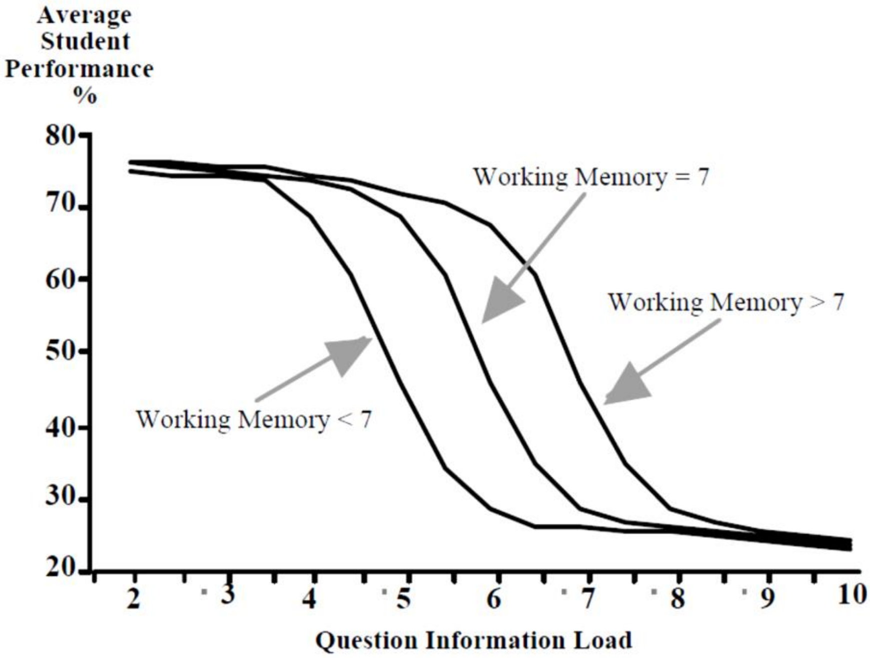


*Figure 4: The decreasing performance of students due to working memory overload (Reid, 2008, p.53)*

The above S-shaped graph was also obtained during a study carried out by Johnstone and El-Banna (1989). During this research, a chemistry problem related to molarity was presented to a group of 16-year old students. While this question seemed very easy to their teachers (who were able to work it out in just four steps), the same question resulted to be more challenging to the students who took around nine steps to complete. Since the number of steps needed to complete the question exceeded the capacity of the students’ working memory, only 9% of the students were able to successfully complete the problem. Johnstone and El-Banna suggest that the latter must have had a strategy with which they could chunk the required pieces of information and eliminate the ‘noise’ from the ‘signal’ such that the question fell within their working memory space.

As can be seen, sometimes students tend to encounter challenging situations where performing one specific task requires them to understand the information being presented to them, extract the useful material from it and hence link it to the data stored within their long term memory. This may be too much for the students to handle all at once, resulting in an overload on their working memory and making the task too difficult to complete (Sweller, Ayres & Kalyuga, 2011). Johnstone and Wham (1982) (as cited in Agustian & Seery, 2017) state that such an overload is not just achieved whilst working mole related problems, but also whilst completing other tasks such as practical work as shown in Figure 5 below.

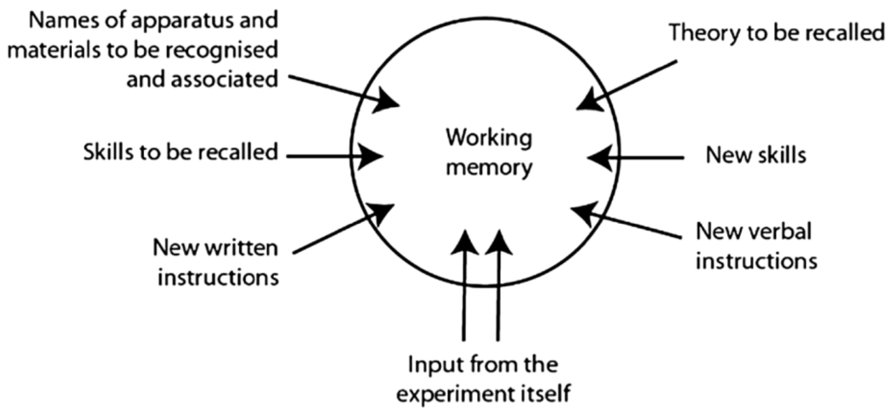


*Figure 5: The overloaded working memory of a student during a practical session. (Johnston and Wham, 1982 as cited in Agustian and Seery, 2017, p. 524).*

To the teacher, whose working memory is well-organized, concepts may seem to be well-structured, well-presented, linked and hence easy to follow. In contrast, this may not be so to the learner who may look at the incoming information as if it does not have any order at all and hence, choosing which of the information is useful and which is not can be demanding. Due to this reason, many teachers might think that it would be helpful if they present the students with fully structured ideas as this would reduce the overload on the students' working memory (Johnstone, 1984). However, for students to truly understand and internalize concepts, the organization and linking of information has to be done solely by them. If this is not so, students may fall in the trap of opting for rote-learning, trying "to reduce the content to selecting the appropriate equation to answer questions – rather than work toward chemical understanding" (Seery, 2014, p.1566).

### 2.3.3 The Language Used

Many feel that learning chemistry is like "stepping into another world", that it is "like another language" or that it "is absolute Greek" (Boddey & De-Berg, 2015, p.221). This is because "not only do students need to understand the symbols, terminologies, and theories used in learning chemical concepts, but they also need to transform instructional language or materials that teachers use in the chemistry classroom into meaningful representations" (Chiu, 2005, p.1).

One aspect of this multifaceted problem is the fact that the vocabulary used in chemistry is quite extensive. In fact, it has been found that students learning chemistry in secondary school are exposed to more new words than when learning a new foreign language (Groves, 1995). Some of these terms have Greek or Latin roots to which students are not accustomed to and hence find them difficult to process. For example the suffix 'escence' in Latin refers to the beginning of an action and is found in words such as efflorescence, effervescence, luminescence and incandescence (Sarma, 2006). Other technical terms are highly specific and students come across them only a few times. As a result they remain alien to the students. Such words include amphoteric, homologous and hygroscopic. Other words may look very similar in writing like alkane and alkene whilst others sound very similar like isotope and isomer. These also pose many difficulties for the students (Childs, Markic and Ryan, 2015).

Another obstacle that students encounter whilst studying chemistry is the fact that some words that are commonly used in our everyday language have a different meaning in chemistry. For example, in everyday life, if sewage water is converted to first class water and is hence potable, it is referred to as 'pure'. However, in chemistry that same water is not considered to be 'pure' because although it is drinkable, it still has other minerals dissolved in it (which are harmless to our body). Other words which are used interchangeably in our everyday life may also have different and specific meanings in chemistry (Fensham, 1994). An example of such words are melting and dissolving, where only one word "jinħall" is often used to refer to both instances in our Maltese language. Furthermore, in chemistry certain catchphrases are used to explain particular phenomena. For example, one of the phrases that are frequently used is the fact that 'ions carry a charge'. Such an expression, if not clearly illustrated, may cause students to think that ions carry electrons around in a "piggyback fashion" (Garnett & Treagust, 1992, p.132). Hence, if teachers use these terms whilst explaining certain concepts without stopping to explain what these words/phrases actually mean, misconceptions may arise.

Learning chemistry does not only require students to start looking at commonly used words in a scientific way, but it also entails the mastering of scientific symbols. Marais and Jordaan (2000), identify three types of symbolisms used in chemistry. Firstly, there are the letter symbols, which are usually used to represent the elements, for example Na for sodium or Fe for iron. Then, there are the icons like the $\rightarrow$ or the +. Finally, there are symbols which are a combination of the first two types, like $Ca^{2+}$or °C. If students are given a question which, for example, includes the equilibrium process taking place during the Haber process ($N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$), they have to pass through many cognitive steps before answering the given question. For example, by looking at the given equation they have to:

i) Determine what the given elements and compounds are from their symbols and formulae.
ii) Recognise the fact that $NH_3$ is a compound made up of one nitrogen atom and three hydrogen atoms.
iii) Discern that the coefficients show that one molecule of nitrogen is reacting and combining with three molecules of hydrogen to produce two molecules of ammonia.
iv) Establish that for every mole of nitrogen, 3 moles of hydrogen are needed in order to produce 2 moles of ammonia.
v) Decipher that the + means 'reacts with' instead of 'added to' as is interpreted in maths.
vi) Identify the $\rightleftharpoons$ and realize that the reaction is reversible and that the forward and backward reaction occur at the same time.
vii) Pin-point the fact that all the reactants and products are gaseous and therefore the reaction is homogeneous.

Only after going through all of these symbolic interpretations would the student then be able to answer the given question (Marais & Jordaan, 2000).

Other language barriers that are experienced by many students worldwide include the fact that some students learn chemistry in English, a language which is foreign to students whose native language is, for example, French or German. Some find scientific words (like element or conductor) difficult to process whilst others find linking words (such as 'hence' and 'as a result of') or exam language (for example, compare, evaluate and infer) hard to understand. Furthermore, scientific communication does not rely solely on words but also on pictures, graphs, tables and diagrams which can also act as sources of confusion for the students (Wellington & Osborne, 2001).

According to the information processing theory, as explained in Section 2.2.2., when new information is presented to the students, it is first filtered such that only recognizable and appealing material passes into the Short-Term Memory. This means that if the language used in order to study chemistry is not firstly rooted in the Long-Term Memory, students will find it difficult to find any connection between the new material and that already established. As a result, many will resort to rote-learning where the data would only be stored temporarily. Furthermore, if the new material does make it into the Short-Term Memory, students would be faced with the problem that in the limited space available they have to hold the new information and at the same time transform the intricate and unfamiliar language into a more recognizable form. Requiring a lot of space, such a task will very often result in an overload on the working memory and hence, learning would not occur (Johnstone & Selepeng, 2001).

### 2.3.4 Misconceptions

According to Ausubel (1968) "the most important single factor influencing learning is what the learner already knows" (p. vi). This means that for meaningful learning to occur teachers must firstly get acquainted with what knowledge the students already hold in their Long-Term Memory. This is because students are not 'tabula rasa'. In fact, according to the constructivist theory, as explained in section

2.2.3, students enter our classrooms with a set of previously conceived ideas. Hence, when they are approached with new material they tend to assimilate it with the previously acquired data. Therefore, it is utterly crucial that teachers make sure that the concepts held by students are in line with those accepted by the scientific community. If this is not accomplished, students will build inaccurate connections, giving rise to false ideas known as misconceptions (Salierno, Edelson & Sherin, 2005).

Barke, Hazari and Yitbarek (2009), suggest that misconceptions can fall into one of two categories as follows:

i) **Self-developed misconceptions:** Students tend to note how the world around them works and then use their logic in order to explain their observations. For example, students may notice the moon reflecting the sun's light during the night only to conclude that the moon is a source of light. In another instance, young children may have held an ice-cube in their hand and observed it melting. Hence, they may conclude that if one squeezes an ice-cube it will disappear (Pine, Messer & St. John, 2001).

The language students hear other people use in order to describe certain observations, may also lead to the strengthening of certain misconceptions. For example, people describe the fact that we have day and night by stating that the sun rises in the morning and sets in the evening. This may lead students to believe that it is the sun that moves around the earth and not the other way round (Barke, Hazari & Yitbarek, 2009).

ii) **School-made misconceptions:** Some concepts, such as those concerning atoms, are surely not dealt with in a student's daily life. Hence, any misconceptions regarding such matter are undoubtedly made in the classroom. In fact, textbooks and diagrams tend to be one source of alternative notions. For example, in textbooks atoms are shown to be made of orbitals surrounding the nucleus. If teachers do not help students interpret such diagrams, students may think that orbitals are actually physical circles in which electrons reside (Nakiboglu, 2003).

The language used by teachers in order to describe certain concepts may also contribute to the development of misconceptions. For example, when describing a water molecule a teacher might simply say that it is made up of hydrogen and oxygen. This may lead students to think that water consists of a homogenous mixture of hydrogen and oxygen atoms rather than the fact that water is a molecule consisting of two hydrogen atoms covalently bonded to one oxygen atom (Garnett, Garnett & Hackling, 1995).

As can be seen, learning chemistry tends to involve a lot of thought, reflection and contemplation, due to the numerous abstract concepts it contains. Some of these theoretical concepts, such as the nature of matter, atomic structure and chemical bonding, are quite fundamental and they are in fact the stepping stones for more advanced concepts. If students attempt to learn more elaborate concepts without a good grasp of the foundations, they will inevitably end up in an endless struggle trying to understand chemistry (Nakhleh, 1992).

### 2.3.5 Motivation

In the book 'The Adventures of Tom Sawyer', Mark Twain (1876) writes that:

> [Tom] had discovered a great law of human action… namely, that Work consists of whatever a body is *obliged* to do, and that Play consists of whatever a body is not obliged to do. And this would help him to understand why constructing artificial flowers or performing on a treadmill is work, while rolling ten-pins or climbing Mont Blanc is only amusement (as cited in Lepper & Henderlong, 2000, p.257).

According to the Self-Determination Theory, students behave in a certain way because they are either intrinsically motivated (where performing a task instils in them a certain pleasure) or extrinsically motivated (where the completion of a task is driven by external reasons such as the reception of rewards) or because they are totally amotivated (they lack any of the former types of motivation) (Deci, Vallerand, Pelletier & Ryan, 1991). As described in Section 2.2.1, in the early 20$^{th}$ century, scholars were only interested in studying how certain behaviours can be brought about through extrinsic motivation. In fact, studies were dominated by research where rats (Skinner, 1965) and cats (Thorndike, 1898) amongst other animals, were taught to press bars, levers or buttons in order to gain food or water or to put a stop to the experienced pain (external forces of motivation). However, several studies began to emerge later on in the century that showed that, if presented with tasks that provide adequate challenges, are fun to complete, arouse curiosities, are relevant to everyday life and empower individuals with the ability to make their own choices, students are more likely to become intrinsically motivated (Malone, 1981).

Research shows that intrinsic motivation is much more effective than extrinsic motivation. This is because unlike intrinsic motivation, extrinsic motivation leads to only short-term changes and does not help to maintain a certain behaviour for life. In addition, with external rewards, students are less likely to feel self-fulfilled and eventually reinforcements are less likely to remain effective (Harpine, 2015). In a study carried out by Lepper, Greene and Nisbett (1973), the effect of extrinsic rewards on intrinsic interest was studied. A group of children who were intrinsically motivated to draw were subjected to one of three situations. The first group of students agreed to draw in order to obtain a reward, that is, a certificate. The second group of children engaged in the same activity and they were rewarded with the same certificate after finishing the task. However, these students knew nothing about the reward until after they had completed their drawing. The last group of children carried out the same activity as in the previous groups. Contrastingly, they were neither promised nor given a surprise reward after accomplishing the given task. One or two weeks later, the same task was carried out with the same groups of students only to find that the children who had received a reward before spent less time drawing than those who did not receive one at all.

Unfortunately, many studies show that some students are academically amotivated and they tend to engage in surface learning (Pintrich, 2004), procrastination (Lee, 2005) or drop out of school or their studies (Gewertz, 2006). In turn, extensive research was conducted in order to pin-point the reasons as to why students get immersed in such behaviours. Erb (1996) found that lack of motivation could be due to the fact that students were not being given responsibility for their own learning, they had a low self-esteem or they were experiencing family problems.

Other factors were more related to the delivery of the lesson itself. For example, Barlia (1999) states that students can become disengaged if they find no relation between the given task and its application in real life, or if emphasis is given to the memorization of vocabulary or information rather than the gain of true understanding. In another study carried amongst science students Hynd, Holschuh and Nist (2000) found that factors like grades, self-efficacy, the expectation of others (like parents), future targets and personal interest in the subject all contributed to the level of students' motivation.

Academic motivation impacts students' learning, their behaviour, as well as their attainment. "It can direct behavior toward particular goals, lead to increased effort and energy, increase initiation of, and persistence in, activities, enhance cognitive processing, determine what consequences are reinforcing [and] lead to improved performance" (Bhoje, 2015, p.76). In a longitudinal study carried out by Murayama, Pekrun, Lichtenfield and Vom Hofe (2013), the relationship between motivation, cognitive learning strategies, intelligence and the students' improvement in mathematics was studied. It was found that at first, intelligence, motivation and cognitive learning strategies were all linked to the students' increase in performance. However, over the years, it was established that motivation and cognitive learning strategies have the largest impact on students' achievement rather than intelligence.

Applying the same parameters discussed above to chemistry as an academic subject, one can conclude that students are likely to do better in chemistry if they are intrinsically motivated and if the social environment is conducive to it. Unfortunately, some studies (Zusho, Pintrich & Coppola, 2003; Gottfried, Fleming & Gottfried, 2001) have reported a decrease in motivation amongst chemistry and science students along their school years. This was mainly due to the increased difficulty in the subject's content, a decrease in students' self-efficacy and a decrease in student achievement. These factors lead to a lack of intrinsic motivation, which, in itself, is a barrier to further students' learning, thus leading to a vicious circle of amotivation.

## 2.4 Flipped Learning

### 2.4.1 What is Flipped Learning?

Although very simplistically, flipped learning is usually defined as 'a method where the work done at home is switched with that done at school', in actual fact flipped learning entails more than just that.

> Flipped Learning is a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter (Flipped Learning Network, 2014, p.1).

In fact, teachers may create a flipped classroom where they assign students texts or videos which they can go through at home but they may fail to establish a flipped learning environment. For teachers to truly engage in flipped learning they must create learning spaces based on the following four F-L-I-P pillars identified by Hamdan, McKnight, McKnight and Arfstrom (2013):

**i) Flexible Environments:** No two flipped classrooms look alike since there is no such thing as 'the flipped classroom'. However, one thing that all flipped classrooms have in common is that they allow students to learn in a variety of ways.

Firstly, students are allowed to learn new material when and where they like, as long as they are prepared for the upcoming lesson. This is because flipped classroom teachers tend to videotape themselves giving lectures, create their own videos with screen-capture software and accompanying voice-over instructions and make use of ready-made online resources such as YouTube videos (Roel, Reddy & Shannon, 2013). This gives students the chance to view the provided material on their portable technological equipment such as mobile phones, laptops and tablets at any given time or place.

At a more advanced stage, students may be allowed to learn at their own pace and they will not be required to complete a task in the same time frame as the others within the same class/course. On the contrary, they are given a set of objectives and activities which will help them reach the required aims. Once they accomplish a particular goal, they are assessed by their teacher and when they feel ready they can then move on to work on the next objective. By employing the 'Flipped Mastery Technique' one would hence find students within the same classroom engaged in a different activity. While some students may be carrying out an experiment, others may be taking an assessment test, another group of students may be watching a simulation on their personal tablet, whilst another group of students may be having a discussion with their teacher (Bergmann & Sams, 2012).

This means that teachers within a flipped classroom have to be flexible enough not only to physically rearrange the desks, tables and other classroom furniture in order to ensure that all the students can carry out different activities in a comfortable and well-adapted environment but also to create and employ different learning strategies as well as assessment tasks (Hamdan, McKnight, McKnight & Arfstrom, 2013).

**ii) Learning Culture:** Some critics "believe that flipping is simply a high-tech version of an antiquated instructional method: the lecture" (Ash, 2012, p.6) and hence still a teacher-centred technique. However, flipped learning is not about using videos in order to teach students. On the contrary, it is about how class-time can be used more efficiently in order to increase direct contact time with the students and engage them in activities that help them gain higher-order thinking skills (Sams & Bergmann, 2013).

In 1956, Benjamin Bloom, a cognitive psychologist developed a list of learning objectives that are related to the cognitive, affective and psychomotor aspects of education. He ranked these objectives according to their complexity, that is, those which are factual at the bottom going to the more intricate and abstract at the top. In a traditional classroom, where the teacher introduces and explains a new concept in class, the students would only be able to reach the bottom three objectives, that is, remembering, understanding and applying. In turn, the students are expected to reach the top three, most challenging objectives, that is, analysing, evaluating and creating, when they are on their own at home through the work assigned by their teacher. This contrasts with what takes place in a flipped classroom where the less demanding objectives are reached by the students at home and hence class-time is freed such that the teacher can organize activities through which the students, with his/her guidance and support, can attain the more higher-order objectives as can be seen in Figure 6 (Lopes & Soares, 2018).

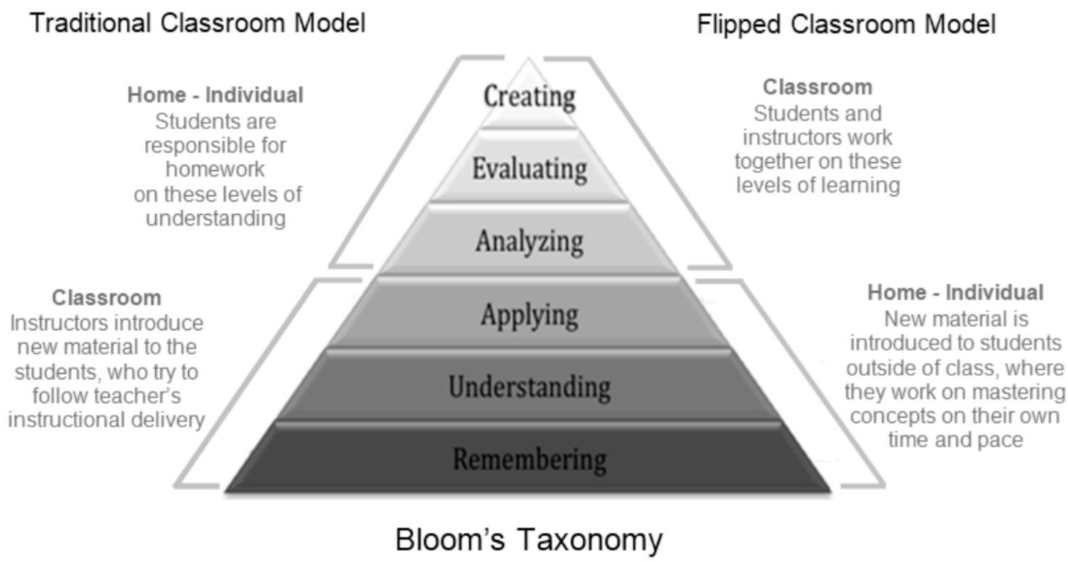


*Figure 6: Bloom's Taxonomy as applied in a traditional and flipped classroom (Lopes & Soares, 2018, p. 3847)*

**iii) Intentional Content:** Freed from lecturing and the passing on of factual information during class-time, teachers have more time to spend in direct contact with their students, helping those who are struggling and challenging those who have grasped the presented concepts well. This means that they are able to move away from a 'one-size fits all' approach and more towards differentiated teaching, recognizing the fact that different students possess an array of different intelligences (Sams & Bergmann, 2013).

According to Howard Gardner, students are in possession of one or more different types of intelligences such as linguistic, musical, mathematical-logical, spatial, bodily-kinaesthetic, interpersonal, intrapersonal and naturalistic (Nolen, 2003). However,

> people are not necessarily intelligent because they have a potential, talent, or innate ability. Rather, people can demonstrate intelligence because of the manner in which they perceive, comprehend, adapt to new situations, learn from experience, seize the essential factors of a complex matter, demonstrate mastery over complexity, solve problems, critically analyse, and make productive decisions. . . . human beings are not necessarily intelligent because they have potential or talent; we all know someone who have wasted or damaged both their potential and their talent because they did not think intelligently. (Denig, 2004, p. 100-101)

Therefore, it is the teacher's responsibility to plan lessons that incorporate within them an array of pedagogies, such as problem-based learning, peer tutoring, group work, role-plays, and experimental tasks amongst others. In this way, teachers would be able to reach out to different students who have different needs, giving them the opportunity to understand, learn and ultimately reach their potential.

iv) **Professional Educator:** A question that might pass through one's mind is: "if the knowledge that has made today's university instructors the "experts" in their fields is so readily available, what role should the expert be playing within the classroom?" (Wallace, Walker, Braseby & Sweet, 2014, p. 259). According to Carl E. Wieman, the associate director of the White House Office of Science and Technology Policy, teachers are cognitive coaches who deduce what students need in order to do well and infer what methods are suitable for the students to reach their aim. In addition, they motivate pupils to put as much effort in their work as possible and also provide them with effective and constant feedback (Berrett, 2012).

This means, that in a flipped classroom even the roles of the teacher and the students are switched. In a traditional classroom, students are expected to sit in rows in front of their desks, quietly listening to the expert, 'the teacher' covering the required syllabus whilst taking down dictated notes (content acquisition). In turn, after class the students are expected to cram as much information as possible such that they are able to regurgitate everything in exams. This contrasts with what happens in the flipped classroom where students are expected to take ownership of their own learning, participate actively in classroom activities, ask questions and solve real-life problems (content application). In the meantime, teachers, who are not just knowledge experts but pedagogical specialists (which is what differentiates them from other professions), prepare appropriate activities and materials which help to scaffold students' learning. They also assess students in a formative manner, provide them with constructive feedback, help them clear any misconceptions that they might have and guide them, support them and encourage them whenever they feel lost. In this way, teachers create learning communities where learning is less content driven. Instead more emphasis is placed on the creation of activities that engage students in the acquisition of higher-order skills (Wallace, Walker, Braseby & Sweet, 2014).

### 2.4.2 Advantages of Flipped Learning

The benefits of flipped learning have been recognized by numerous teachers worldwide and in fact this pedagogy is being used with students of all ages in order to learn different subjects. For example Makrodimos, Papadakis and Koutsouba (2017) used the flipped learning technique to teach Maths, Geography and History to a group of 11-year old students attending a primary school in Greece. In Saudi Arabia, this technique was used by Al-Harbi and Alshumaimeri (2016) in order to teach English grammar to their 16-17 year old students, for whom this is a foreign language. A group of Australian University students also experienced the flipped learning approach whilst in their final year of their Bachelor of Actuarial Studies course (Butt, 2014). Unfortunately, this pedagogy is not well-known amongst Maltese teachers and hence a dearth of studies have been conducted regarding this approach. In this section, a summary of the advantages experienced by foreign students and teachers is going to be given. This will hopefully aid Maltese teachers to reflect on their teaching methods and help them consider adopting this technique within their classrooms.

The buzzwords 'active-learning', 'student-centred pedagogies' and 'inquiry-based learning' have long since prevailed in discussions regarding education both nationally (Ministry of Education and Employment, 2012) and abroad (Rocard at al., 2007). However, research shows that although their advantages are well known amongst teachers, traditional teaching methods are still being highly used. In a research carried out by Owen, Dickson, Stanisstreet and Boyes (2008) in the UK, 79% of the students reported that during their physics lessons they spend a lot of time listening to their teacher's explanations, copying down notes (76%) and working out written tasks (65%). These findings are in line with those found in Malta during a research carried out by Borg (2013), where it was established that the three methods that were mostly used in physics classrooms were the lecture method, where the passive passing on of information occurs, the completion of written worksheets as well as the carrying out of 'recipe-type' experiments.

When Maltese science teachers were specifically asked why they are not making use of student-centred techniques within their classrooms, one of the most recurring answers obtained in several studies was due to time constraints (Bonello, 2016; Borg, 2014; Farrugia, 2015; Gatt, 2011). In a particular teacher's own words: "although it is beneficial to students' learning, one has to bear in mind that this is quite time consuming, therefore it is impossible to carry out such an exercise at a frequency which one would like" (Farrugia, 2015, p. 292). By employing the flipped learning technique within their classrooms, these teachers would be able to free-up class time in order to carry out more hands-on and inquiry-based activities which provide students with a richer learning experience. In a study carried out by Aidinopoulou and Sampson (2017) amongst a group of 5$^{th}$ graders attending a primary school in Greece, it was found that within a scholastic term, during traditional history lessons, around 220 minutes were spent on lecturing whilst only 115 minutes were spent on student-centred activities. This contrasts with the fact that when the same lessons were carried out using the flipped learning technique 440 minutes were solely spent on 'history thinking skills cultivation activities' whilst no time was spent on lecturing.

With more time available for the students to engage in hands-on activities thereby developing higher-order thinking skills, teachers who employed the flipped learning approach with their students have observed an increase in their students' attainment and motivation levels. For example, in a study carried out by Peterson (2015), two groups of students attending Knox College in the United States, were taught statistics using one of two contrasting methods, that is, either through the lecture method or the flipped learning technique. In the latter group, where students had the opportunity to interact with the lecturer, participate in pair-work activities trying to solve challenging questions as well as engage in individual quizzes through which feedback was obtained, it was found that in their final exam these students achieved significantly higher grades than their peers who attended lecture sessions. In addition, all of the participating students within the flipped classroom expressed their satisfaction with this method of teaching. Similar results were obtained in a study carried out by Day and Folley (2006) amongst undergraduate students attending Georgia Institute of Technology. Once again it was noted that, students who engaged in the flipped learning approach outperformed the students attending a traditional lecture in every assignment, project and test that was given.

As one can notice, even the job of the teacher changes. Instead of being the focus of attention, the spotlight is shifted on to the students, instead of engaging in one way communication, more student-student and teacher-student interaction is encouraged, instead of teaching students, learning becomes a process that unique individuals pass through hand-in-hand with their teacher and instead of fostering passive students, teacher embed within their students the love for learning, enthusiasm and motivation, encouraging them to become active and independent learners. As Jennifer Douglass, a teacher at Westside High School, Macon in Georgia, who has flipped her classroom states:

> teaching under a traditional model is draining. I feel like I have to “perform”, which requires energy, enthusiasm, and a “you are on-stage” effort at all times. I remember last year driving into work, thinking, “Man, I feel like just being a student today. I wish I could go in and let someone else do all the work – be in the passenger seat for once”. When I switched over I felt *free*. I was able to go in and watch my students work. I don’t mean that I sat back and drank coffee – I stayed busy interacting one-to-one; working with kids who were struggling; addressing questions that students had that I never had time for before, really getting to know my kids. It is just that the burden of learning had traded hands. And you know, really, it had to be passed on. I can’t force someone to learn – they have to accept that responsibility for themselves. This

> method allows them to clearly see that – and gives them a structured environment that ensures success (Bergmann & Sams, 2012, p.17).

Using the flipped learning technique, teachers would also be able to adjust their lessons based upon their students' needs. In Malta, in the scholastic year 2014/2015, banding was introduced in schools in place of streaming in order to promote differentiated teaching. In a study carried out amongst teachers and students in primary schools by Grech and Muscat (2015), it was found that one of the limitations teachers experience when trying to implement differentiated teaching within their classrooms was time. They feel that their syllabus is too vast in order to allocate time to get to know their students interests and their needs and adjust their teaching accordingly when at the same time they have to finish teaching the syllabus in time for the students to be able to do their exams.

The flipped learning technique can be used in order to reach out to all students even though they may have different needs and achievement levels. For example, students who struggle the most can get the most individualised help during class time, thereby enabling them to be successful which, in turn, increases their motivation to learn. Brett Wilie, a teacher in Dallas, Texas claims that "some of the students that have struggled in the past (according to their parents) are doing much better because of my ability to work with them more one-to-one in class, helping with objectives they are having trouble with" (Bergmann & Sams, 2012, p.23). In a study carried out with 23 at risk 9$^{th}$ grade students in a government school in America, it was found that when the flipped learning technique was used, failure rates decreased drastically by 31% in Mathematics, by 33% in English, by 22% in Science and by 19% in Social Studies. In addition, even the students' behaviour improved and in fact disciplinary actions were reduced by 66% (Flumerfelt & Green, 2013). Moreover, due to the flipped learning approach, the number of students who do not usually complete their homework due to the fact that they find it too difficult to accomplish decreases. This is because students are subjected to challenging questions in class, where the teacher is available to guide the students to reach the desired goal (Marlowe, 2012). Gifted students also benefit from the flipped learning approach. This is because teachers would be able to provide them with more advanced material for them to explore and also present them with challenging tasks and questions that would enable them to develop their creativity and critical thinking skills. Moreover, the fact that students are given the material to study at home, enables them to go through it as quickly as they wish, skimming through parts they are already familiar with and delving into parts which they still need to master (Siegle, 2014).

Flipped learning is favoured by many students since it incorporates a tool that 21st century students have grown with, technology. On average students text 3,000 times each month. They all have a Facebook, Twitter and Instagram account which they use in order to communicate with their friends. They are surrounded by smartphones, laptops and tablets where information is just a click of a button away at anytime and anyplace (Bender, 2012). Therefore, with such a reality how can technology not be incorporated in today's classrooms? The flipped learning pedagogy is very in line with current technologies since many teachers have opted to use podcasts, vodcasts (Bergmann & Sams, 2009) and home-made videos (Mason, Shuman & Cook, 2013) in order to pass on to their students the information that is going to be discussed in class. This is very beneficial to the students since this allows them to pause, stop and re-hear explanations as need be (Roach, 2014). Even students who may have missed a lesson due to sickness, or perhaps due to the fact that they have attended another school activity, may find these videos useful since it makes it easier for them to catch up (Fulton, 2012). In addition, having students hearing new concepts and technical terms before class enables them to start assimilating the new knowledge hence decreasing their working memory load (Abeysekera & Dawson, 2015). Other teachers who have embraced flipped learning have used technology not just for the distribution of information but also to evaluate students through the use of concept mapping (Biljani, Chatterjee & Anand, 2013) and quizzes using 'Clickers' (DeLozier & Rhodes, 2017).

### 2.4.3 Challenges of Flipped Learning

Although the flipped learning approach has numerous advantages, this pedagogy does have a few challenges. Firstly, getting used to this approach takes time. Teachers cannot expect that students embrace this technique overnight, after being exposed for a number of years to traditional teaching, as this requires a shift in mentality. For instance, when a group of University students were asked whether they prefer the flipped learning technique over the chalk-and-talk method after just one semester of being exposed to the former approach, students expressed their frustration that their lessons were packed with different activities, feeling that they were always ‘on-the-go’ moving from one task to another. They also disliked the fact that the given classwork questions were very different from what they are used to in the usual home works and exam (Strayer, 2012).

In fact, not every study carried out reported that students within a flipped classroom performed significantly better than others in a traditional classroom. Some stated that although students were more motivated and enjoyed the lessons much more when the flipped learning technique was employed, there was no difference between their final exam results and those obtained by the students who attended the traditional classes (Love, Hodge, Grandgenett & Swift, 2014). Other studies (Hagen & Fratta, 2014) reported that students participating within the flipped classrooms underperformed due to the fact that they had the total responsibility of their own learning and hence they felt that they were not very prepared for their exams. This is because during the usual lectures, their teacher used to emphasise important points and hence the students would know what they have to study for their exams.

Undoubtedly, the flipped classroom technique does put on a lot of responsibility on the students and for this pedagogy to work well, students do need to be intrinsically motivated. If not, teachers have to provide extrinsic motivation. For example, one challenge that teachers who have tried out this approach found was, that not all the students carried out the tasks they were assigned when they went home. These teachers suggest that firstly, teachers should explain and emphasise the importance of watching the videos and going to class prepared (Cavalli, Neubert, McNally & Jacklitch-Kuiken, 2014). In addition, teachers can prepare short quizzes at the beginning of the lesson based on the tasks that were designated to be done at home and the mark gained on these quizzes would carry a small percentage of the final exam's mark (Stayer, 2007).

Although the constructivist approach is supported by many scholars, others have found that pedagogies that rely on this method of learning are not as effective as one might think. Krishner, Seller and Clark (2006) state that techniques such as discovery learning that offer students very little guidance, do not take into account the cognitive structures of individuals, that is, they do not bear in mind how the working and long-term memory function. They maintain that

> we are skilful in an area because our long-term-memory contains huge amounts of information concerning the area. That information permits us to quickly recognize the characteristics of a situation and indicates to us, often unconsciously, what to do and when to do it. (Krishner, Seller & Clark, 2006, p. 76).

As described in Section 2.2.2, our working memory is very limited in that it can only hold new information for a very short amount of time. However, when a piece of information found in the long term memory is retrieved and moved in the working memory such restrictions are no longer present. This means that information can reside in the working memory for a longer period of time whilst being manipulated hence resulting in further learning. This can be achieved by direct instruction. On the other hand, when students are presented with new information with minimal accompanying guidance, this information stays in their working memory for a short while and although a number of attempts are made such that this information is connected to that in the long-term memory few connections are made due to the lack of guidance. On the contrary, it would only contribute to the overloading of the working memory preventing further learning (Krishner, Seller & Clark, 2006).

Other criticisms pointed out include the fact that the flipped classroom technique entails that students spend a lot of time in front of a screen when one should try and limit screen time (Bergmann & Sams, 2012). In addition, when students are in front of a screen, they are very often distracted as they try to do more than one thing at a time. For example a student might watch a video and at the same time communicate online with his/her friends. Moreover, watching a video does not ensure that a student has understood everything and if questions arise, students do not have the possibility to ask their teacher there and then. All of these difficulties may arise given that the students have access to a computer and internet once they are at home (Milman, 2012). Furthermore, before employing the flipped learning technique, teachers are not only expected to be computer literate, but they are also presumed to be up-to-date with today's innovative technology in order to be able to either make their own videos or else to find and share suitable videos, animations and simulations with their students (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur & Sendurur, 2012). A lot of preparation time would also be required (Puarungroj, 2015).

## 2.5 Conclusion

Learning is a process where the received information is filtered a number of times based on previously acquired knowledge with which it is then accommodated and assimilated. It is a process that has to be solely done by the student him/herself. The teacher's job is simply to act as a facilitator, creating the appropriate learning environment the students need to create their own knowledge, encouraging them when they lose hope, guiding them in order to reach their objectives and offer their support when needed.

Needless to say, such a complex journey does not come without its difficulties. For example the nature of chemistry in itself offers students quite a struggle. With its intricate language and abstract concepts, misconceptions may easily arise. In addition, the vast amount of knowledge that students have to know and study may cause an overload on the students' working memory.

The flipped learning technique (whose history may be viewed in Appendix 1) is a pedagogy that may be used in order to combat these difficulties. This is because when students are assigned videos to watch at home in order to gain crucial knowledge, students would have the opportunity to pause, rewind and rehear the video as many times as they want. This will expose the students to the new language that is being used and the new concepts that are going to be discussed in class. Hence students will be able to start digesting the new incoming material before going to class, at their own pace, thereby reducing their working memory load. In addition, class time is more importantly used for hands-on activities where with the aid of their teacher, students will be able to gain higher order thinking skills becoming better problem-solvers.

Due to the lack of research on the effectiveness of the flipped learning technique within classrooms in schools in Malta, this study aims to shed light on how this technique can be used to teach the chemistry topic ‘Nature of Matter, Atomic Structure and Chemical Bonding’. In addition, the students’ performance and views with regards to this technique will be analysed.

# Chapter 3

# METHODOLOGY

# Chapter 3: Methodology

## 3.1 Introduction

In this chapter, the methods and aspects concerning the implementation of this study will be discussed. Firstly, the background in which the study is carried out will be established. This will be followed with the statement of the objectives behind the study as well as an analysis of the strategies employed for the execution of this research. The design of the study as well as the research tools used will be evaluated with emphasis on issues such as validity, reliability, triangulation and ethics. Finally, the way the data collected were evaluated and analysed will also be discussed.

## 3.2 Background Setting of the Study

### 3.2.1 The School System in Malta

In Malta, education is compulsory between the ages of five and sixteen and students may attend one of three different types of schools, that is, a state school, a church school or an independent school. In the latest survey carried out by the National Statistics Office (NSO) (2018), it was found that during the academic year 2016/2017, 57.6% of students attended a state school, 29.2% went to a church school whilst 13.2% were enrolled in an independent school. Since this study was carried out in a state school, some information regarding the state school sector will be provided in the next section.

### 3.2.2 The State School Sector

State schools are organized into colleges. Each one consists of:

- A number of primary schools, that is, one for every village within the college's catchment area. During the primary years students study a number of subjects including science, religion and social studies. However, at the end of Year 6, they sit for a benchmark exam in Mathematics, Maltese and English only.
- A middle school in which they complete their first two years of secondary school. At the end of Year 8, students choose their subjects of specialisation, one of which may be chemistry.
- A senior school, where students spend their last three years of their compulsory schooling preparing for the SEC exam.

Each of these schools has its own Head of School. However, all the schools are managed by one College Principal. In addition, state schools endorse a co-ed system within every schooling level. Although the maximum number of students per class within a senior school is 26, in chemistry (as well as in other subjects which make use of a workshop or lab), the maximum number of students per class is 16.

### 3.2.3 The Research Sample

This case study was conducted amongst 15, Year 9 students within a co-ed secondary senior state school in Malta. These students had very diverse achievement levels and their motivation towards learning varied as well. This group of students was chosen since I was going to be teaching them chemistry during the same year the study was conducted.

The fact that I was working within the same school I was going to conduct my research in proved to be quite advantageous, both in the acquisition of consent from the School Principal and the Head of School, as well as in the planning and scheduling of the focus group. Having a timetable with the same schedule as the students meant that the focus group could be carried out on the last day of their half-yearly exam such that none of the students' lessons, exams or activities were disrupted. Moreover, the fact that I was able to teach the students another topic for two whole months before conducting my research helped me get to know my students better and start developing a trusting relationship with them. As a result, students could feel more at ease whilst sharing their opinions and views both in their reflective journals and during the focus group (Cohen, Manion & Morrison, 2000).

## 3.3 Aims of Study

This study was designed to implement the flipped learning technique and to monitor the views and its impact on the performance of fifteen Year 9 students. The topic, 'Nature of Matter, Atomic Structure and Chemical Bonding', was chosen since it is one of the most crucial topics in chemistry, with the theories involved being the stepping stones of future concepts (Taber & Coll, 2003). Unfortunately, in literature, numerous studies (Talanquer, 2011; Gilbert & Treagust, 2009; Chittleborough & Treagust, 2007) report that students worldwide are finding this topic to be problematic as described in detail in Section 2.3.

In order to investigate how to make this topic more student-centred and to combat the difficulties experienced by many students whilst dealing with the concepts involved, my research questions were:

i) How can the flipped classroom technique be used in order to teach the topic 'Nature of Matter, Atomic Structure and Chemical Bonding'?
ii) What is the impact of this technique on students' performance with respect to the learning outcomes as specified in the chemistry syllabus?
iii) What are the students' views on the flipped classroom approach with regards to their engagement, motivation and learning?

## 3.4 The Strategy Employed

The approach selected for this study was mainly a qualitative approach, a case study, since the emphasis is on the production of thick descriptions of the experiences, feelings, views and opinions of a particular group of students in a specific setting rather than on the generation of statistical data coming from a larger population. Literature regarding qualitative research and case studies is presented in the following sections.

### 3.4.1 Qualitative Research

According to Erickson (2012), the main aim of qualitative research is

> to document in detail the conduct of everyday events and to identify the meanings that those events have for those who witness them. The emphasis is on discovering *kinds* of things that make a difference in social life; hence, an emphasis is placed on *qualita*s rather than on *quantitas* (p.1451).

This type of research was ideal for the execution of my study since it enabled the narration and hence, explanation, of how the flipped learning technique was being experienced by a specific group of students. In addition, being an inductive process, it lead to the formulation of new concepts which "attempt to explain social processes" and "form a platform for new inquiries" (Yin, 2011, p.9).

Trustworthiness is one of the issues concerning qualitative research. In this study this was achieved through a number of ways, including:

i) The use of multiple sources of data. Triangulation, "adds rigor, breadth, complexity, richness, and depth to any inquiry" (Devetak, Glažar & Vogrinc, 2010, p. 79).
ii) The well-documentation of the collected data which was made available for everyone to view and scrutinize. This increased transparency.
iii) The accuracy by which the data was reported. It was clearly stated which data were collected from the students' point of view and which were gathered from my perspective.
iv) The adherence to evidence collected when data were presented. In fact, the participants' words were used in order to back it up.
v) The allowance of space for the discovery of new concepts (Yin, 2011).

Qualitative research can be carried out using a variety of methods. However, the method chosen for the execution of this research was the case study. This was thought to be suitable since it enabled me to not only approach the situation under study from my point of view but

> to view the world with the eyes of the examinees, to describe and take into account the context, to emphasize the process and not only the final results, to be flexible and develop the concepts and theories as outcomes of the research process (Devetak, Glažar & Vogrinc, 2010, p. 78).

### 3.4.2 A Case Study

According to Yin (2009), "a case study is an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context" (p.13). It requires the researcher to penetrate a situation not of a whole organization but rather of a unique person, group or community. This enables one to "enter the scene with a sincere interest in learning how they function in ordinary pursuits and milieus" (Stake, 1995, p.1).

This study can be described as a case study since it has several features as identified by Creswell (2007):

i) It concerned a particular group of students, within a specific school and within a set time frame.
ii) It involved the gathering and evaluation of data from two sources, that is, from the students' personal experiences and the teacher's observations.
iii) An array of methods (as discussed in Section 3.5) were used in order to collect data. In this way, an in-depth and a rich, well-detailed picture of the on goings under study were provided. These descriptions were used to identify themes that can be used to explain the findings uncovered during the study.
iv) Whilst analysing data, discoveries were organized in a chronological order and evaluated.
v) "Assertions" (Stake, 1995, p.9) were made in order to derive an overall understanding of the collected data.

According to Cohen, Manion and Morrison (2000), "case studies strive to portray 'what it is like' to be in a particular situation" and "hence it is important for events and situations to be allowed to speak for themselves rather than to be largely interpreted, evaluated or judged by the researcher" (p. 182). Therefore, whilst reporting findings, care was taken so that journalism, selective reporting, pomposity and blandness were avoided. Triangulation of data, (which is further discussed in Section 3.7) helped to eliminate these issues as much as possible.

## 3.5 The Research Tools

During this study, several research tools were used. Firstly, lesson plans and resources were constructed such that the topic 'Nature of Matter, Atomic Structure and Chemical Bonding' could be tackled using the flipped learning technique. Students' opinions, views and feelings regarding this approach were then collected through multiple methods. These include teacher observations, the use of student reflection journals, a focus group and a Likert-scale questionnaire. An end-of-topic test was also prepared from which I was able to determine whether the students had truly grasped the intended learning outcomes or not. These research tools are discussed in more detail in the following sections.

### 3.5.1 Design of Chemistry Lessons using the Flipped Learning Technique

In order to carry out this study, lesson plans and resources that can be used to teach the topic 'Nature of Matter, Atomic Structure and Chemical Bonding' were prepared. First, the learning objectives of this topic were identified from within the MATSEC Chemistry syllabus. The established objectives were then sorted into two groups, that is, those that can be achieved through inquiry and those that can be learned better through direct instruction due to their factual nature. Based on the latter, a student homework pack (Appendix 5) was created. This pack consisted of worksheets which the students had to complete at home in preparation for the next lesson. These contained the following features:

i) Task objectives. This is because “when students are aware of the connection between an activity and the lesson objective, this awareness can guide their work and support their learning” (Reed, 2012, p. 22).

ii) Links to You-Tube videos. These offered students a flexible learning environment (Hamadan, McKnight, McKnight and Arfstrom, 2013) and helped students realize that technology can be a useful tool for their studies. In addition, they were also very convenient, since I spent less time recording and editing my own videos and more time on the planning of effective student-centred activities.

   Since the main tasks were based on videos, it was made sure that all students had access to a computer and to the Internet. Students were informed that if they did not have access to the Internet at home, they were to approach me so that I could give them the downloaded videos on a portable storage device. Moreover, students were told that if they do not have an access to a computer at home, they were able to use the school library’s computers during break time or during a replacement lesson.

iii) Video follow-up questions. These were set in order to help the students think about the concepts presented, to check their level of understanding and to serve as a starting point for the lessons carried out at school.

   This is because the topic ‘Nature of Matter, Atomic Structure and Chemical Bonding’ was taught using the partial flipped method and only certain concepts (Appendix 4) were introduced to the students as tasks to complete on their own at home. It was thought that flipping all of the topic, or allowing the students to work at their own pace and not within a certain time frame, or having students carry out a different learning activity at the same time whilst in class was not ideal. This is because this was the students’ first flipped learning experience. Being used to a more traditional approach, where a new concept is first introduced in class, is explained by the teacher and then homework is given based on the concept that would have just been discussed, such a sudden, drastic change would have been too overwhelming for the students. This may result in frustrations and resistance towards any of the proposed changes (Bland, 2006).

When students came to class, they were hence prompted in order to explain in their own words the concepts they had learned at home, ask questions and voice their difficulties. They were also encouraged to peer tutor each other, participate in group work activities and carry out formative assessment tasks upon which constructive feedback was provided. The latter tasks can be viewed in Appendices 6 and 7.

### 3.5.2 Observations

According to Marshall and Rossman (2006), "observation entails the systematic noting and recording of events, behaviors, and artefact (objects) in the social setting chosen for study" (p. 98). It involves, the studying of a situation in situ, such that the researcher would be able to gain a better understanding of the context in which the study is taking place, generate theories based on first-hand experience, notice aspects that the unconscious mind would have otherwise missed, detect things that participants might be unwilling to discuss during interviews, collect data that is not contaminated with the perceptions of others and gather secluded information (Cohen, Manion & Morrison, 2000).

Gold (1958), states that a researcher can take one of four roles in order to carry out observations, that is, a complete participant, a participant as observer, an observer as participant or a complete observer. Since during this study, I was both the researcher and the classroom teacher implementing the flipped learning technique, and the participating students were aware that I was observing them for research purposes, I can be viewed as a participant observer.

During this study, I observed the students throughout all the lessons regarding the topic 'Nature of Matter, Atomic Structure and Chemical Bonding'. Through observations, I was able to witness the degree to which students engaged with the flipped learning technique, which tasks motivated the students the most and what difficulties and misconceptions they possessed. In addition, I could observe how the students collaborated together in order to peer tutor each other and hence complete the given tasks. The way students dealt with the given feedback and their level of independence, responsibility and ownership over their own learning was also noted. Hence, "detailed, nonjudgmental, concrete descriptions of what has been observed" (Marshall & Rossman, 2006, p.98) were compiled in a journal after each lesson.

Being simultaneously a teacher and a researcher has several advantages, such as "having a greater understanding of the culture being studied, not altering the flow of social interaction unnaturally and having an established intimacy between the researcher and participants which promotes both the telling and the judging of truth" (Bonner & Tolhurst, 2002, p. 8-9). However, there are several ethical considerations that one has to take care of whilst employing this dual role. These will be discussed in Section 3.8.

### 3.5.3 Students' Reflective Journals

According to Hedlund, Furst & Foley (1989), a reflective journal is an "interactive instrument" since "it engages the writer in a dialogue with the self" (p.106). In fact, it also tends to differ from any other academic writing since whilst the latter emphasize content and knowledge, a reflective journal focuses on the student's experiences, thoughts and feelings whilst interacting with the concepts involved (Locke & Brazelton, 1997).

During this study, the students made use of a reflective journal in which entries were made during the last ten minutes of every lesson. Since it was the students' first time using a reflective journal for educational and research purposes, they were given a set of questions (Appendix 8) in order to help them think and reflect on how they felt throughout their journey whilst making use of the flipped learning technique. Through the students' writings, I was able to gain feedback on what they liked or disliked, what difficulties they encountered and how they felt whilst carrying out the assigned tasks both at home and at school. In addition, I was able to determine whether the students' views regarding the flipped learning technique changed as they progressed through the topic. Even though the aim of the reflective journal was first and foremost for research purposes, I believe that it was a very good opportunity for the students to become more self-aware of who they were as learners, to become more engaged with the learning material involved and to be more reflective and hence more self-directed in their studies (Park, 2003).

When students are asked to write their thoughts and feelings in a journal they are asked "to open themselves up to us by using their individual voice, expressing a sense of honesty, and taking a risk in the content they write" (Pavlovich, Collins & Jones, 2009, p. 4). From the students' side this requires courage since it is not easy to admit one's weaknesses and appear vulnerable in someone else's eyes. Hence, for journaling to be successful a sense of trust must be developed between the teacher and the students (Wagner, 1999). Thorpe (2004) found that in order to encourage students to write detailed reflections, some teachers tend to notify their students that their journal entries will be assessed and marked and hence will contribute towards their final grade. Creme (2005) states that, on the one hand, this does encourage students to put effort in their writings because when teachers assess students' work, they are sending a message that they consider that piece of work to be important. However, when students are graded, they tend to end up writing what they think is expected of them instead of what they truly feel and think. Hence, during this study, students' journals were not graded. Instead, students were simply encouraged to write what they feel in order to provide me with feedback on whether they liked the flipped learning technique, as their opinions could influence whether this technique would be used later on whilst they learn other topics.

### 3.5.4 The Focus Group

A focus group is “a small gathering of individuals who have a common interest or characteristic, assembled by a moderator, who uses the group and its interactions as a way to gain information about a particular issue” (Williams & Katz, 2001, p. 2). During this research, a focus group was carried out in order to gain a deeper understanding of the students’ views regarding the flipped learning technique. It was a way of empowering the students, allowing them to voice their opinions and explain in detail how they felt whilst carrying out the tasks both at school and at home when this new approach was implemented. In addition, it served as an opportunity to discuss issues that did not emerge through the use of other data collecting methods. Such issues include, how students dealt with the tasks whilst they were at home, what they used to do whenever they missed a lesson and how they used to tackle difficulties whilst working within a group. Students’ views regarding issues like those linked to homework were also unveiled. The focus group carried out was audio recorded in order to “preserve a permanent record of the proceedings” (Greenbaum, 1998, p. 2).

The focus group, which lasted for around 35 minutes, was carried out with ten students, who sat comfortably on cushions which were arranged in a circular manner in a Personal, Social and Career Development (PSCD) classroom. According to Krueger and Casey (2002), a focus group consisting of six to ten participants is ideal since it is “large enough to gain a variety of perspectives and small enough not to become disorderly or fragmented” (p. 656). In addition, settings which offer participants a relaxed and comfortable environment and that enable them to view each other well, tend to set the ideal atmosphere for the discussion to take place. During the focus group, I had the role of the moderator and hence, as the leader of the discussion, I had to instil in the participants energy and enthusiasm to continue exchanging views and debating during the whole session. This is because “interaction among participants is a vital part of the focus group process and must be encouraged to maximize the quality of the output from the session” (Greenbaum, 1998, p.66). In fact, this is one of the characteristics that distinguishes focus groups from other methods of data collection such as one-to-one interviews. In addition, instead of continuously asking direct questions, I used a set of pre-prepared questions (Appendix 9) to prompt the participants to elaborate on their answers and encourage them to react to each other's views and opinions. This is because during a focus group, it is the "participants who primarily guide the flow and direction of questioning" (Williams & Katz, 2001, p. 4). In turn, the moderator's job is to find a balance between "keeping the discussion on track, yet allowing for a degree of spontaneity" (Greenbaum, 1998, p.85).

The use of the focus group enabled me to collect a large amount of data in a short amount of time (Cohen, Manion & Morrison, 2000). In addition, the fact that students were not interviewed on a one-to-one basis helped, to "encourage the participation of those who are wary of an interviewer or who are anxious about talking" (Kitzinger, 1995 p.301). However, the same group dynamics that make focus groups advantageous to use, also have their down-side. This is because, during a discussion, the participants' opinion is made public and hence, some may hesitate from stating what their true views are in fear that they may be later on shamed or punished by the other members of the group (Greenbaum, 1998). Hence, caution was taken such that none of the participating students dominated the group in a way that made the others feel that one particular opinion is better than any other.

### 3.5.5 The Questionnaire

"The questionnaire is a widely used and useful instrument for collecting survey information, providing structured, often numerical data… and often being comparatively straightforward to analyze" (Cohen, Manion & Morrison, 2000, p. 245). Questionnaires can include either open-ended questions or closed-ended questions such as dichotomous, multiple choice, rank ordering and rating scales (Siniscalco & Auriat, 2005). During this study, a rating scale questionnaire, more precisely, a Likert-scale questionnaire (Appendix 10) was distributed to the participating students after the completion of all the lessons utilizing the flipped learning technique.

A Likert-scale questionnaire was chosen for various reasons. Firstly, it allowed me to gain an overall view of every students' opinion regarding the different aspects of this pedagogy as well as factual information regarding their journey both in and out of class when this approach was used. Close-ended questions which required only a circle around the number on the scale displaying their thoughts, encouraged the students to answer all the questions. This is because the questionnaire took a very short time to complete (around ten minutes) and it did not require the students to think how to articulate their responses and hence put them down in writing. This was especially important since the students were already asked to write their own personal reflections in their journal after every lesson and they were to attend a focus group during which further explanations could be given. Most probably, if students had been asked to answer further open-ended questions they would have been discouraged, giving only brief answers which would have contributed very little towards the collected data. Moreover, a rating scale was chosen over dichotomous yes/no questions since the former "permit[s] the possibility of increased measurement precision" (Nemoto & Beglar, 2014, p. 5).

The questionnaire used in fact consisted of a 6-point scale; 1 being 'Strongly Disagree' and 6 being 'Strongly Agree'. The even-numbered scale implied that the students were required to choose a side. However, they were free to leave any questions unanswered had they truly no opinion or were unsure about the given statement. This is because according to Baumgartner and Steenkamp (2001), if a neutral response is available, students may opt for it due to "evasiveness" and "indifference" (p.145). This view is however not shared by all scholars. Nowlis, Kahn and Dhar (2002) state that if the middle response is not available and "the respondents are truly neutral, then they will randomly choose one or the other side of the issue" (p.319).

Once the type of questionnaire to be used was decided upon, the statements that were constructed were written in a way such that they were well understood by the students and at the same time enabled the collection of the required data. Literature was used in constructing the statements (Passmore, Dobbie, Parchman & Tysinger, 2002). These were short, made use of only simple vocabulary, required only one answer (not double-barrelled), contained no double-negatives and were not leading (Siniscalco & Auriat, 2005). Most of the statements were written in a positive way. However, negatively-worded statements were also included since they tend to act as "cognitive speed bumps that require respondents to engage in more controlled, as opposed to automatic cognitive processing" (Podsakoff, MacKenzie, Lee & Podsakoff, 2003, p.884).

Although questionnaires are a very good way of gathering a large amount of data in a very short period of time, they do not come without their limitations. These include the fact that consisting of closed questions only, students may wish to elaborate on their answers but are not given the chance to do so. The interpretation of the intensity of the scales may also vary from one person to another. In addition, some students may not want to appear as extremists and hence may avoid choosing the 'strongly agree' and 'strongly disagree' options for that reason (Cohen, Manion & Morrison, 2000). Therefore, to reduce these short-comings as much as possible, the questionnaire was in fact used alongside other data collection methods.

### 3.5.6 The End-of-Topic Test

After the lessons regarding the topic 'Nature of Matter, Atomic Structure and Chemical Bonding' were complete, students were required to sit for an end-of-topic test to enable me to determine whether the students had truly grasped the concepts involved. The test (Appendix 11), was designed in a way such that each question tested a particular learning outcome as identified in the MATSEC syllabus. In addition, the test questions were very similar to those found in the SEC past papers, both in the language used as well as in the level of difficulty. However, it was made sure that these were not beyond the students' cognitive level.

## 3.6 Validity and Reliability

For a study to be considered as credible and trustworthy, it must demonstrate that special attention was given to issues of validity and reliability that might have been a threat to that same research. According to Leung (2015), validity "means "appropriateness" of the tools, processes and data" (p.325). It also refers to "the precision in which the findings accurately reflect the data" (Noble & Smith, 2015, p. 35). On the other hand, reliability is another word "for consistency and replicability over time, over instruments and over groups of respondents" and "for research to be reliable it must demonstrate that if it were to be carried out in a similar context… then similar results would be found" (Cohen, Manion & Morrison, 2000, p. 117).

According to Brink (1993), sources of error that can affect the validity and reliability of a study can be classified as being due to the following:

i) the researcher;
ii) the participants under study;
iii) the setting in which the research takes place;
iv) the research tools used and the data analysis method.

Firstly, since students knew that they were being observed for research purposes they might have acted in a different way than if they had not been observed. In addition, they may have opted to refrain from letting me know their true views and instead they may have only provided me with information that they thought would either put them in the best light or that would be much more pleasing to me (Greenbaum, 1998). However, this was counteracted by the fact that apart from being a researcher, I was also their teacher and therefore I was no stranger to them. On the contrary, they were already accustomed to my presence in class and I had already built a trusting relationship with them (Cohen, Manion & Morrison, 2000). In addition, the students were made aware of the aims of the study and of the fact that their identity was going to remain anonymous and that they could opt out of the study with no negative consequences, which made them feel more at ease in revealing their true thoughts (Brink, 1993).

The research tools themselves may also have been a threat to the reliability and validity of the gathered data. For instance, during the study a focus group was carried out in order to get a deep insight of the students' views. Although this research tool can be considered as valid since it does have the potential to reach this aim, it may be considered as unreliable due to the fact that when the students have to state their opinions in front of others they may feel pressured or influenced by their peers in order to adhere to one particular opinion (Greenbaum, 1998). Further threats may be present during the data analysis process. This is because as discussed in section 3.4.1, qualitative research generates textual data and hence the researcher has "to make sense and recognize patterns among words in order to build up a meaningful picture without compromising its richness and dimensionality" (Leung, 2015, p. 324). Whilst doing so it is very difficult for the researcher to be objective because "as observers and interpreters of the world, we are inextricably part of it; we cannot step outside our own experience to obtain some observer-independent account of what we experience" (Maxwell, 1992, p. 283).

In order to combat the threats experienced, two measures were taken. Firstly, detailed accounts of the procedures used were provided. This is because, being a case study, the results obtained cannot be generalized. However, the same research method can be used so that other similar studies can be carried out. This means that although the study is non-generalizable, it is highly relatable. In addition, thick descriptions of the observations made are provided and the students' own words are used as much as possible during the reporting of the results (Shenton, 2004). Furthermore, triangulation of data was used such that the same scenario could be looked into from different perspectives (Wiersma & Jurs, 2009). This is explained in the next section.

## 3.7 Triangulation

Triangulation can be achieved in different ways. During this study, methodological triangulation was used. According to Bryman (2004) "triangulation refers to the use of more than one approach to the investigation of a research question in order to enhance confidence in the ensuing findings" (p. 1). This is because, "exclusive reliance on one method… may bias or distort the researcher's picture of the particular slice of reality she is investigating. She needs to be confident that the data generated are not simply artefacts of one specific method of collection" (Cohen, Manion and Morrison, 2000, p. 112). By triangulation the data obtained from different sources are compared in order to determine whether there is corroboration, that is, "convergence of the information on a common finding or concept" (Wiersma & Jurs, 2009, p. 287). Therefore, the more data are gathered from different sources, the less chance there is that the researcher reaches false conclusions and hence the more valid the study is.

During this study, triangulation of data was carried out through the use of four different methods of data collection. These include a diary in which I kept an account of the observations I made after every lesson, the students' reflective diaries in which they jotted down notes at the end of every lesson, textual data obtained from the focus group as well as data gathered from the Likert-scale questionnaire that was filled by the participating students.

## 3.8 Ethical Considerations

Ethical considerations were extremely crucial during this study, due to the dual role I had as a teacher and a researcher. This role placed me in a difficult position due to the "tension between trying to be systematic and thorough [as a researcher] and trying to be responsive and compassionate [as a teacher]" (Hoong, Chick and Moss, 2007, p.5). Wong (1995) depicts this conflict by recounting an episode where students in a classroom grew restless while he probed a girl to explain the answer she gave earlier even deeper. This is because as a researcher he wanted to see how students explain certain concepts. Wilson (1995) disagrees with Wong saying that "to teach [the girl], to help her clarify her confusion, to examine closely what happens—these are legitimately the agenda of both the teacher and the researcher" (p.20).

Dadds and Hart (2001), agree with Wilson stating that this type of research which they call ‘practitioner research’ is “a central commitment to the study of one’s own professional practice by the researcher himself or herself, with a view to improving that practice for the benefit of others” (p. 7). In order to address this dual role, I kept my teaching goals in mind when I was in class, making sure that all the learning outcomes were being reached by the students. Then, when I was outside the classroom, I reflected and analysed my pedagogies as well as the students’ reactions and doings, keeping my research aims in mind.

For instance, the flipped learning approach was used with all the students within my class since it caters for the different needs of all students and is beneficial to all. However, it was up to the students to decide whether they were willing to participate in the study by writing down their thoughts in their reflective diary and voicing their opinions during the focus groups. In addition, even if they decided to participate, they were free to opt out of the study whenever they liked without any penalties such as deduction of marks with respect to their assessments, tests or exams. In fact, in order to make sure that the students did not feel pressured in participating in this research, a senior member of staff was asked to be present whilst I explained the purpose of my study, distributed the information sheets and consent forms and asked the students whether they would like to participate or not. The presence of a critical friend helped ensure that the students were free to choose whether they wished to participate, given my dual role as their teacher and researcher. Moreover, the focus group was not carried out during class time so that only the students who wished to participate would attend.

Before carrying out this study, ethical clearance was obtained from the Faculty Research Ethics Committee (FREC) and the University Research Ethics Committee (UREC). Then, permissions were requested from the Directorate for Quality and Standards in Education (Appendix 2), so that I was able to carry out this research in a state school. Permissions were also sought from the School Principal and the Head of School in order to carry out my research within their school. Once all the necessary permissions were obtained, consent forms (in both Maltese and English) were given to the students and their parents/guardians. Both parties were given an explanation of the nature and purpose of the study. In addition, students were assured that any collected data were going to remain confidential and that neither their names nor the name of school they attend would be mentioned in the study. Instead pseudonyms were to be used. A copy of the distributed permissions and consent forms are found in Appendix 3.

## 3.9 Data Analysis

According to Ryan (2006), "analysis is the process of coming up with findings from your data. The complete process of analysis requires the data be organised, scrutinised, selected, described, theorised, interpreted, discussed and presented to a readership" (p.95). Due to the qualitative nature of this study, the data generated was rather text-based. This was mainly achieved through focus group transcripts, observation notes and students' reflective journals. Data were hence analysed using the inductive/grounded theory approach. This "involves analysing data with little or no predetermined theory, or structure or framework and uses the actual data itself to derive the structure of analysis" (Burnard, Gill, Stewart, Treasure & Chadwick, 2008, p. 429). This was carried out in five steps as identified by Pope, Ziebland and Mays (2006):

i) <u>Familiarisation</u> – I read the collected data very thoroughly for numerous times so that I familiarised myself with them. This allowed me to identify any recurring key words, beliefs, views and feelings.

ii) <u>Identifying a thematic framework</u> – The identified key words were then used in order to establish themes, arguments and concepts (all of which were given a numerical code) through which data could be analysed. All of this was done in the light of the research questions. During this stage, the number of categories were reduced quite considerably.

iii) Indexing – The textual data was then read once again. However, this time, it was annotated with the numerical codes established in the previous step. These were sometimes supported with further explanatory notes scribbled in the margins. By the end of this procedure, the data were divided into more manageable pieces.

iv) Charting – Hence, an excel chart was formulated such that each piece of data were rearranged according to its theme. In this way, data could be easily retrieved and referred to when needed.

v) Mapping and interpretation – Finally, the previously constructed charts were used in order to establish links between the data and the research questions as well as with theoretical frameworks formulating a "reality" of the case study under investigation.

Data regarding students' views with respect to the flipped learning technique were also obtained through a Likert-scale questionnaire. Due to the close-ended questions present in this questionnaire, quantitative data in the form of numbers was generated. This was inputted manually into a spreadsheet according to the question number. The degree up to which students agreed/disagreed with the given statements was hence reported alongside the qualitative data obtained to support the arguments made.

Finally, an end-of-topic test was also distributed to the students in order to determine whether the intended learning objectives were reached by the students. After the students' test answers were marked, each answer was analysed such that if it was completely correct, it was said that the student had completely achieved the learning intention. However, if a student's answer was only partly correct or completely incorrect, it was said that the learning intention was partially achieved or not achieved accordingly. A bar chart demonstrating the number of students who achieved/partially achieved/not achieved each and every learning objective was hence plotted. The marks students obtained in their end-of-topic test were also compared to the marks they achieved in their half-yearly exam, taking only into consideration those questions regarding the topic 'Nature of Matter, Atomic

Structure and Chemical Bonding'. A Pearson correlation test was hence carried out in order to check whether there was any correlation between the two sets of results.

## 3.10 Conclusion

In this chapter, the background setting of the study, followed by a detailed explanation of the method employed and the research tools used during the implementation phase were given. Justifications for the choice of method and tools used were also provided. Issues of validity, reliability, triangulation as well those concerning ethics were also discussed. Finally, a detailed account of the process by which the data were analysed was provided.

# Chapter 4

# Data Analysis and Discussion of Findings

# Chapter 4: Data Analysis and Discussion of Findings

## 4.1 Introduction

The data collected during this research will be presented, evaluated and discussed in this chapter. Firstly, the students participating in each part of the study will be presented. Then, the analysis of the results will be divided into two parts. The first part will focus on the pre-class preparation phase. Therein, the effect of the flipped learning technique on the students' cognitive load as well as their motivation is going to be analysed. The second part of the chapter is then going to focus on how the flipped learning technique was made use of during class time. The identification of misconceptions, the importance of inquiry, peer tutoring, the teacher's provided support, assessment and feedback will be evaluated.

In the last part of the chapter, attention will be given to the students' performance with respect to the learning outcomes outlined in the chemistry syllabus. The students' readiness to take responsibility of their own learning and their willingness to engage in the flipped learning technique will likewise be considered.

## 4.2 The Participants

As described in Section 3.2 of the Methodology chapter, this study was carried out with the fifteen Year 9 students I was entrusted to teach chemistry to the same year I carried out my research. Hence, the flipped learning technique was used with all of the students within my class since it caters for the different needs of all the students and is beneficial to all. However, it was up to the students to decide whether to participate or not in the data collection process through the use of the reflective journals, Likert-Scale questionnaire and the focus group. Table 1 shows the number of students who accepted to participate in each of the data collection phases.

Table 1: *The number of students participating in each of the data collection phases*

| Data collection tool | Number of students participating (out of 15) |
|---|---|
| Reflective Journals | 14 |
| Focus Group | 10 |
| Likert-Scale Questionnaire | 14 |

## 4.3 Pre-Class Preparation

As indicated in Section 3.5.1, students participating in this study were given short tasks which they had to complete at home prior to the lesson. In this section, the effect of these tasks on the students' cognitive load as well as their motivation will be discussed.

### 4.3.1 Reduction of Cognitive Overload

When students were asked how they felt about the fact that whilst dealing with the topic 'Nature of Matter, Atomic Structure and Chemical Bonding' they were given a task to do at home in order to prepare for the next lesson, all of the participating students stated that they liked this new approach. One of the main reasons was that "I'll get to know what I will be learning in the next lesson and it will give me like a heads up and I'll get the feel about what the subject is" (Student L, Focus group). This shows that the students are certainly interested in their studies and would like to be mentally prepared about what the lesson is going to be about. They feel that being introduced to the concepts that are going to be discussed in class will boost their level of understanding.

The topic 'Nature of Matter, Atomic Structure and Chemical Bonding' is quite a factual topic, filled with abstract concepts and scientific terminology. From personal past experience, within a one hour twenty minute traditional double lesson, there is a tendency that a lot of new material is introduced. One such lesson would be the one regarding the structure of the atom where it is revealed that atoms are made up of protons, neutrons and electrons, that these have a particular charge and mass and students are shown how to determine the number of each sub-atomic particle within a particular atom from its mass number and atomic number. From previous experience, usually such a lesson is quite overwhelming for the students and by the end of it, they would feel that their brain is overloaded with new material. In addition, when given related exercises to work out on their own, some students would not even know from where to begin and how to handle the given information.

This contrasts with the way students participating in this study felt. When the same exact lesson was flipped and all the material was firstly introduced to the students at home, it was observed that whilst in class, not only could they explain these concepts on their own but they also started making certain deductions such as the fact that hydrogen is the only element with no neutrons. In addition, students were able to work out all the given exercises on their own with very minimal prompting after working out just a few examples together with their teacher. One student even wrote in her reflective journal that “The tasks weren’t difficult at all because I paid attention to the video” (Student O, Reflective journal, 27 Nov 2017).

This finding goes well in line with the information processing theory that was discussed in Section 2.2.2. It was maintained that, information gathered from the senses is transferred to the Working Memory Space so that it is processed, made sense of and hence stored in the Long Term Memory. However, the Working Memory Space was said to have a finite capacity and hence, if it is fed with too much information at once, it will get overloaded and will cease to work. Cognitive overload can be of three types: intrinsic (which is generated by the level of difficulty of the subject being taught itself and hence maybe difficult for the instructor to alter), germane (which may arise due to the way students process and construct information in order to generate schemas) or extraneous (which is due to the way in which information is presented) (Van Merriënboer & Ayres, 2005).

The topic ‘Nature of Matter, Atomic Structure and Chemical Bonding’ is one that requires the addressing of all three levels of ‘Johnstone’s Chemistry Triplet’ as described in Section 2.3.1. This is because at the beginning of the topic, students may be first presented with several everyday scenarios, such as a drop of food colouring placed in a bowl of water, or someone applying perfume. In each case, students have to describe what they think will happen (the macro and tangible stage) and then explain their predictions/observations in terms of particles (the submicro stage). Later on, students learn how to draw the structure of atoms, how to illustrate the way different atoms bond, how to write the formulae of different compounds and how to calculate the Relative Atomic Mass (R.A.M.) of atoms that may have several isotopes (the representational stage). This means that this topic has a high intrinsic cognitive load. According to Sweller, Van Merrienboer and Paas (1998),

> when dealing with high element interactivity material, because intrinsic cognitive load is high, it may be vital to reduce extraneous cognitive load in order to reduce total cognitive load to manageable proportions…. Appropriate instructional designs can reduce extraneous cognitive load and redirect learners’ attention to cognitive processes that are directly relevant to the construction of schemas (p.265).

This was achieved through the use of the flipped learning technique as explained in further detail below.

Firstly, the way the students’ worksheets were constructed helped the students focus on the important concepts they were expected to learn and disregard other irrelevant material that would otherwise overload their working memory. For example, the objectives given at the beginning of each handout helped the students direct their attention towards the material they were required to learn. For instance in the worksheet ‘What are atoms made up of?’ one of the objectives was ‘To determine the number of subatomic particles in different atoms’. Knowing this, the students were able to pay extra attention when in the given video, the narrator started to explain how the mass number and the atomic number of an element reveals how many protons, neutrons and electrons that particular element has. Students confirmed this when in the focus group they stated that “I used to see it [the video] once. Then, I used to see it again, press pause and write” (Student L, Focus group) showing that whilst watching the video they knew exactly what they had to look out for. The way the text in the handouts was positioned – kept at a minimum, written in point form and not in chunks, written in a sequential manner with important phrases or words written in bold or in large caps, given a prominent position and accompanied with complementary images – also helped the students concentrate on what was expected of them. In fact, seven of the participating students disagreed, four strongly disagreed and one slightly disagreed with the statement in the Likert-scale questionnaire that stated 'I found the tasks given at home too difficult for me'. This was further confirmed by one of the students when he wrote in his reflective journal "The task was not that difficult because we had instructions" (Student K, Reflective journal, 22 Nov 2017).

The extraneous cognitive load was further decreased by the choice of videos, that students were required to watch in order to complete the given tasks. As suggested by Brame (2016), the videos chosen made use of signalling, that is, they contained cues such as the appearance of key-words and relevant images or animations that helped to make crucial concepts memorable. By drawing the students' attention to them, the burden (due to being novice learners) of having to decipher which are the most important concepts and which are not was removed, hence decreasing their extraneous load. The advantages of signalling was further complemented by the fact that the information provided was segmented into small pieces which could easily be handled by the students. This is because the given videos were rather short varying from 1 minute and 35 seconds to a maximum of 3 minutes and 43 seconds.

Furthermore, the videos provided were weeded (by the video producers themselves) in such a way that extra features such as sound, excessive animations, elaborate backgrounds and extra information, that are usually found in certain videos, were eliminated, hence reducing the amount of distractions negatively impacting the students' attention. Instead, the videos chosen were designed in a way such that the information being provided by the narrator befitted the pictures being shown on the screen so that they complemented each other, continuing to highlight the important concepts the students were expected to learn, hence decreasing their extraneous cognitive load. This theory was backed by one of the students when she wrote “We didn’t have a lot and the videos requested for us to watch are fun and informative” (Student L, Reflective journal, 4 Dec 2017).

Another aspect that helped to reduce the students’ cognitive load was the fact that students were able to learn at their own pace. This is because one of the environmental factors that affects learning is time, that is, “students successfully learn to the extent that they spend the amount of time they need to learn” (Schunk, 2012, p. 105). This variable is different from student to student because it depends on a number of factors. Firstly, it depends on the students’ competencies, that is, their prior learning and skills acquired. Secondly, it depends on the students’ abilities to understand the material they are presented with, because, as described in Section 2.4.1, some students follow instructions better if given verbally, whilst others are able to grasp the same instructions if they are given pictorially. Thirdly, it depends on the students’ level of development. For example, although all Year 9 students are 13/14 years old, and according to Piaget, at that age, they should have reached the Formal Operational Stage and hence, acquired the ability to understand abstract concepts, this may not be so. This is because students develop at different rates and so a 13/14 year old student who may have reached Piaget’s Formal Operational Stage may be within the same class of a student who although is of the same age, is still within Piaget’s Concrete Operational Stage and hence, finds abstract concepts difficult to process (Santrock, 2008).

Unfortunately, lessons at schools are timetabled, meaning that each and every student within an entire class is given the opportunity to learn the same material within the same timeframe, irrespective of the actual amount of time s/he needs to learn. As a consequence, some students may find it hard to keep up with all the new material and hence give up (Rumberger & Lim, 2008), whilst others who are more willing to learn may try to cram all the information received, maybe even by trying to learn chunks of information by heart, with the consequence of ending up with an overload of a mismatch of information (Seery, 2014).

The flipped learning technique addresses this issue by shifting the gain of knowledge outside the classroom and thus, giving the students the chance to take all the time they need to learn. Whilst at home learning through videos, students were able to press the pause button whenever they felt the need to stop and digest the information they would have just come across. Ten of the participating students, in fact, declared that they used to pause the video every now and then whilst eight students used to see the same video more than once "so that I will know what he's saying exactly" (Student E, Focus group). Students explained that they used to watch the videos with subtitles "because if I didn't hear him properly or if he says something which is not clear enough, I would be able to understand more. Or if he mentions a complicated name and I wouldn't know what it is or how to write it" (Student L, Focus group).

The flipped learning technique had a positive impact on one particular student who normally takes a long time to process information. In fact, in her journal she indicated that she took 1 hour to complete one of the given tasks whereas her classmates only took between 5 to 30 minutes in order to complete the same task. The student herself was aware of this situation because in her reflective journal she once confessed that "some people like me may need a bit more time" (Student D, Reflective journal, 8 Jan 2018). This is a one case scenario, where the student herself has felt the struggle of racing against time in order to keep up with her classmates because the pace of the lesson is usually too fast for her and she is not given enough time to process the information she would have just received. When she experienced the flipped classroom technique and she completed the tasks at home at her own pace, she claimed that "it [the task] was very interesting and they weren't too difficult because I understood them" (Student D, Reflective journal, 22 Nov 2018).

### 4.3.2 Motivation

Motivation, that is, "the process of instigating and sustaining goal-directed behavior" (Schunk, 2012, p.346), is another factor that affects students' learning. In this section, students' motivation or amotivation to accomplish the given tasks at home (part of the flipped learning technique) will be discussed in the light of the expectancy-value model of motivation described by Feather (1992). As the name itself implies, this model states that there are two factors which determine whether a student will perform the given task or not. These are:

i) **Value** – that is, the level of importance students attribute to the task; and
ii) **Expectancy** – that is, the abilities and skills students think they have in order to complete the task.

A student will only complete the given task if s/he both values the task itself or its outcome and expects her/himself to be successful upon attempting to undertake it. Hence, if one of these aspects is missing students will refuse to execute the given work. A summary of this theory is showcased in Figure 7 below:

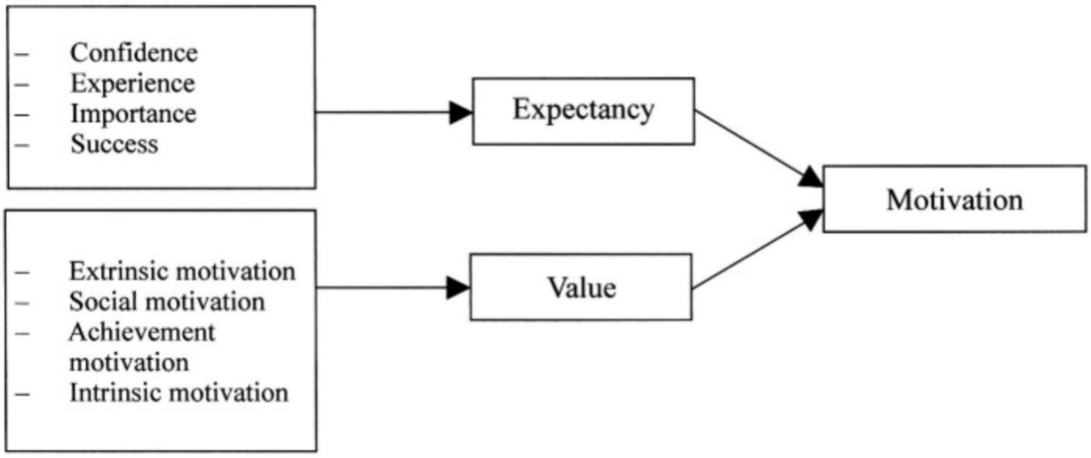


*Figure 7: The Expectancy - Value theory of motivation (Goodyear, Jones, Asensio, Hodgson and Steeples, 2004, p. 181)*

### 4.3.2.1 Value – Why did Students get Involved?

An element that stimulated intrinsic motivation in students and helped them value the flipped learning technique was novelty. Students looked at this approach as a way of how the teacher assigned innovative homework. It is not that they are not used to watching entertaining YouTube videos at home or educational ones at school during lessons. It is the fact that homework, which is usually a monotonous, time-consuming chore that involves the working of numerous and typical exercises, was being transformed into a rather “fun and interesting” (Student C, Reflective journal, 27 Nov 2017) piece of work. This was noted from the numerous comments the students wrote in their reflective journals such as “I enjoyed them because they are different from the rest of the hw” (Student O, Reflective journal, 11 Dec 2017), “I enjoyed it because it was something different than what we usually do” (Student K, Reflective journal, 22 Nov 2017), “I enjoy because most of the teachers give us homework from books and Ms. Schembri told us to watch a mini video” (Student N, Reflective journal, 22 Nov 2017) and “She [teacher] always finds a way to make something new” (Student N, Reflective journal, 6 Dec 2017).

If one had to go down memory lane and try to picture his/her days at school, one would surely remember the day s/he won a prize in a school competition, the time when s/he performed in the school’s talent show in front of a large audience or the day s/he got into trouble. It would be less likely that one remembers the common days that passed by without any particular incidents. The reason is that novel experiences tend to activate the hippocampus in our brain which compares the sensory information received with that stored in the long-term memory. If these are found to differ, the hippocampus sends dopamine to the midbrain which in turn triggers the release of even more dopamine. The sense of pleasure given by this hormone makes us seek new situations which as a result remain cemented in our memory, making them less easy to forget (Lisman & Grace, 2005). Teachers who make use of this finding regarding the human brain and therefore seek to look for innovative ways of how to approach subjects which are naturally not appealing to students, are more likely to attract students’ attention, helping them remain engaged for a longer period of time and boosting their memory. It is also these novel experiences that aid to promote creativity within students since their brains get to be challenged into looking at things from a different point of view, developing new mind sets whilst integrating new information along the way. Unfortunately, things remain novel and intriguing for only a short amount of time because eventually novelty wears off. Therefore, it is very crucial that teachers remain updated with the current trends students feel passionate about in order to continue motivating them.

The fact that technology was being incorporated in the students' learning process also helped to promote students' intrinsic motivation and added value to the given task. In fact, nine of the participating students strongly agreed, while four agreed with the Likert questionnaire statement 'I liked the fact that some tasks involved some technological aspect such as watching videos online'. This was even more evident by the positive remarks the students made during the focus group as well as by comments they wrote in their reflective journals such as "I hope that Ms. Schembri will give us more homework like these" (Student N, Reflective journal, 22 Nov 2017). The videos were clearly pleasing not only to students who are very inclined to schooling but also to those students who are not very fond of school-related work. This was illustrated in the reflections one particular student wrote in her journal: "I don't like homework, but the teacher doesn't give us much and I like watching educational videos so they're a plus for me" (Student L, Reflective journal, 22 Nov 2017) and "I don't like hw much but the powerpoints and videos are entertaining and fun" (Student L, Reflective journal, 29 Nov 2017).

Technology is one of the factors that motivates 21$^{st}$ century students. In fact, in a study carried out by the Malta Communications Authority (MCA) in 2015 amongst students in Malta between school years four and ten (both year groups included), it was found that out of all the Year 9 participating students, 91.4% own a mobile phone, 93.5% have access to the Internet from their own home and 83.5% access the Internet every day. Therefore it seems very logical that the students were motivated by the incorporation of the YouTube videos within the given tasks. When teachers deduce what the interests of their students are and then design activities which are in line with them, they tend to improve the students intrinsic motivation even further (Kahu, Nelson & Picton, 2017). On the one hand, this does not mean that teachers should solely design activities that conform to the students' affections because it is the teacher's role to promote new interests and ideas. In addition, it is impossible to plan an activity that is tailored to each of the students' unique passions all at once. Therefore, rather than trying to create tasks that incorporate each of the students' interest, teachers need to be selective and carefully choose those interests they think are the most worthwhile to extend in order to achieve a particular goal (Touhill, 2012).

YouTube, which was set up in 2005, is a platform on which one can share their personally recorded videos such that they can be seen by millions of people worldwide without any cost. Being so easy to use and being able to reach so many people at once, it has gained a lot of popularity especially amongst teenagers, better known as "digital natives" (Fleck, Beckman, Sterns & Hussey, 2014, p.22). Although it is mostly used for entertainment purposes, it contains an infinite amount of educational videos which can be used to broaden students' knowledge. Videos can be very beneficial as an educational tool. First of all, they tend to be very captivating, grasping the students' attention since they generate sensory curiosity with the changes in light and sound and the attractive animations and graphics they provide. They also tend to arouse the cognitive curiosity of students, making them yearn for even more knowledge (Ciampa, 2014). In fact, nine of the participating students claimed that after watching the videos assigned by their teacher, they used to watch other related videos that were suggested on the side by YouTube itself.

Video animations also help in making abstract concepts more visual, reducing the chances that students form misconceptions that are usually derived from images in books. For example, due to the videos provided, students, especially those with low spatial-ability, were able to visualize what an atom looks like, how electrons orbit around the nucleus of an atom and how electrons are lost by metals and gained by non-metals for the formation of oppositely charged ions. As explained in Section 2.4.1, students learn in different ways. Some are able to process visual information better than auditory knowledge whilst others may prefer to learn by doing things. According to Franzoni & Assar (2009), "if the teaching style employed closely matches the student preferred style of acquiring knowledge, learning becomes easier and more natural, results improve and learning time is reduced" (p. 15). From the Likert-scale questionnaire it was deduced that thirteen of the participating students are more visual learners. This was verified from the students' journals through comments like "I learn a lot more when I see a video" (Student N, Reflective journal, 27 Nov

2017). This further confirms that the choice of videos as a source of knowledge was ideal for the students' needs.

A factor that extrinsically motivated one particular student to engage in the flipped learning technique was the utility value she found in the technique itself, stating that "this can help us learn how to do research on our own as well… for when we go to Junior College or somewhere else" (Student F, Focus group). According to Simons, Vansteenkiste, Lens & Lacante (2004), students who attribute values to future ambitions are said to have an extended 'Future Time Perspective' (FTP) (p.122) and they tend to

> perceive their present behavior as more instrumental because it helps them achieve a broader range of both immediate and future goals (cognitive aspect), and they also value their present task-engagement more strongly because the anticipated value of the future goal is higher (dynamic aspect) (p. 124).

As can be seen, Student F does have an extended FTP because she was able to discern that by employing the flipped learning technique now (present behaviour), she will be able to gain the skills she might need in order to successfully complete her studies beyond secondary school (future goal). It was her extended FTP that in fact motivated her to participate in the flipped learning technique and stimulated her to put more effort in her work.

Being future-oriented, that is, being able to live in the present in such a way that you prepare for the future, is a characteristic that is rarely found in teenagers. However, once they possess it, it impacts their present level of motivation and present behaviour. This is because "developing a long FTP by formulating important, realistic (intrinsic) future goals will foster present motivational striving via the perceived (shorter) psychological distance of future goals and via the perceived (higher) instrumentality of the present for the future" (Lens, Paixao, Herera & Grobler, 2012, p. 326). In fact, students who are future-oriented tend to look at education from a positive point of view, they are more likely to carry out school-related tasks and are good at managing their own time. In addition, they are great at administering their own studies, stay focused for longer periods of time and show a sense of persistence and courage in times when things seem to be too difficult to handle (De Bilde, Vansteenkiste & Lens, 2011). This is because, students who have futuristic goals tend to find the material under study useful in order to help them reach their future targets and hence pressure themselves into working hard in order to reach the desired goals (Lens et al., 2012).

#### 4.3.2.2 Expectancy – What were the Students' Beliefs Regarding their Success?

One of the factors that helped the students decide whether they should complete the given tasks at home or not was their belief about how well they were going to do in the assigned work. In turn, this was affected by other beliefs, two of which are the students' notions of their own abilities as well as their perceptions regarding the difficulty of the presented task.

During this study it was noted that students exhibited different ranges of self-efficacies. Some students had a high self-efficacy and this showed from their level of persistency claiming that "the homework was a bit challenging but I managed to do them" (Student M, Reflective journal, 6 Dec 2017) or "The questions were a bit tricky but I figured them out" (Student G, Reflective journal, 22 Nov 2017). During the focus group the students were asked about what they usually did whenever they were absent from school and consequently, they would not have known which task to complete for the next lesson. Student O replied "I used to ask someone and then I try to do it at home" (Student O, Focus group). This shows that although Student O might have missed a lesson linked to the task that was to be completed at home, she still believed that if she asked her friends what was carried out at school, she could attempt the given task on her own at home and succeed in doing it.

This contrasts with the comment made by Student E whilst replying to the same question:

> No. For example, I never used to ask anyone. However, I used to go to class and I try to understand it from there then… with you. For example, if the

> other's homework is ready I'll try to understand it with you or else if I try to do it on my own I would get mixed up… I think… if I try to do it on my own and I wouldn't know what happened before (Student E, Focus group).

The lack of persistence due to a low self-efficacy was also noted in the statement made by Student L whilst discussing the same question:

> I used to do the same thing. I used to try to do the tasks and watch the video but then if I don't understand something I didn't use to search a lot on my own because I could have got confused… for example mixing the valency number with the number of atoms used… I would have got confused (Student L, Focus group).

In addition, when students were asked whether they used to see other videos besides those requested by their teacher, Student E stated that "No never or else I would have got mixed up… I mean videos linked to what we have done before yes so that I would refresh my memory… but not new things" (Student E, Focus group).

Whilst carrying out a particular lesson, I also noted the students' low-level of self-efficacy (as well as their high level of teacher dependence and poor thinking skills which will be discussed in Section 4.5). The following depicts the observation I made which I hence wrote down in my journal:

> Whilst at home, the students were asked to fill in the speech bubbles of a cartoon in order to recap what they understood in the video that they had just seen. What I noticed was that the students did not use their own words in order to do so but wrote the exact words as stated in the video. Seeing this I prompted the students in order to elaborate on their answers and try to explain what they had just said in their own words. At first, the students hesitated since they did not know how to explain further. It took several attempts and a lot of waiting time until finally the students did elaborate on their answer. In addition, students were not capable of deciding whether the answers they had written at home regarding the experiments they carried out were correct or not based upon the discussion occurring in class and they kept asking me whether they can read their answer out loud so that I will be able to let them know. Moreover, when they knew that their answer was not exactly correct, they were not able to write their own answer based on what was being discussed but they asked me to tell them what the ideal answer is in order to write it down. This meant that a lot of time was spent listening to the students' answers and guiding them in how they can write their answer (Teacher's journal, 22 Nov 2017).

My observation was further confirmed by Student L during the focus group. This is because when I asked the students why they used to watch the video more than once the following conversation took place:

> Student L: So that I would know exactly what he's saying before I start copying.
> Researcher: Copying from where?
> Student L: I always used to use the subtitles with the video.

Furthermore, it was noticed that the level of difficulty of the given tasks, the students' level of self-efficacy as well as the students' rate of completion of the given tasks were linked. This is because whenever the students felt that the assigned work was at the same level of their abilities and hence was doable, they claimed that the task was easy and completed it. On the other hand, when the students felt that the task was too difficult for them to engage in, they did not even attempt it. For example, in order to prepare for the first lesson, students had to watch a video regarding the development of the atomic theory at its early stages as well as perform some experiments which demonstrate diffusion. This was considered to be one of the easy tasks and in fact out of fourteen students (the ones who accepted to write their views in their reflective journals), only two declared that they did not complete their work. One stated that "I forgot" and "because I have a lot of other hw" (Student F, Reflective journal, 22 Nov 2017), whilst the other student did not give a reason why. In addition, Student D, who has a very low self-efficacy, wrote in her journal "They weren't too difficult because I understood them" (Student D, Reflective journal, 22 Nov 2017). Later on, when the concepts that students had to prepare for became more challenging, less students carried out the tasks assigned. For example, when students had to prepare for the lesson regarding ionic bonding, which is a rather demanding concept, the number of students who did not work out the designated work increased to five. Out of the rest, two were absent (so they did not write the reflections) and hence only seven students worked out the given tasks. This time, Student D, who was one of the students who did not complete the appointed tasks wrote "No [I didn't do them] but I think that they were difficult" (Student D, Reflective journal, 8 Jan 2018), showing how her perception of task difficulty as well as her low self-efficacy may have affected her decision of not doing the designated tasks.

These findings are very much in line with Bandura's hypothesis which states that "expectations of personal efficacy determine whether coping behavior will be initiated, how much effort will be expended, and how long it will be sustained in the face of obstacles and aversive experiences" (Bandura, 1977, p. 191). A person's self-efficacy is built along the years and is dependent on a variety of factors such as the amount of praise one receives after accomplishing a task. Another factor is the amount of successes and failures one experiences throughout his life. If one succeeds in most of the tasks he attempts to do, s/he is more likely to have a high sense of self-efficacy than a person who experiences more failures than successes. Students also tend to acquire information about themselves by comparing themselves to others. If a student notices that when a teacher assigns a task s/he always does very poorly when compared to her/his classmates, chances are that s/he develops a rather low self-efficacy. Persuasive comments given by others also tend to have an impact on an individual's self-efficacy. Comments like 'I know you are able to do this' or 'I believe in you' contribute in boosting one's level of self-efficacy. However, one should note that the latter method only works after the individual who receives the said statements or anything similar weighs them in comparison to other factors such as the difficulty of the activity performed, the amount of help received, the level of effort required by the task and the credibility of the person passing on the comments (Schunk, 1991).

Comments such as "No [I didn't do the tasks] but I think that they were difficult" as written by Student D in her reflective journal, show that, some students may have avoided to do the tasks because they believed that its difficulty level was beyond their abilities. According to Schunk (1984), students may acquire information regarding the difficulty of a task from numerous sources. A teacher might simply tell the students that the given task is easy or difficult to accomplish or they may get the cue from the task itself. For instance a long multiplication problem in a non-calculator paper is perceived to be more difficult to solve if it contains a lot of digits. Goal setting is very crucial and challenging at the same time. On the one hand, research shows that if students are given tasks that are easy and they succeed, their level of self-efficacy does not increase as much as when they would have succeeded in accomplishing a difficult task. In addition, if students fail at a task that was classified as easy, the negative impact on their level of self-efficacy would be much greater than if they failed in a task that was perceived as difficult in the first place, especially if they had invested a lot of effort in it. On the other hand, if the students are given tasks that are rather challenging, they may refrain from doing them because they do not have a high self-efficacy in the first place. This means that tasks that promise "success with less effort than expected should strengthen self-efficacy" (Schunk, 1984, p.9-10).

Some students may have a conflict between wanting to complete the task in order to be seen as a success in the eyes of others, and at the same time doubting their abilities and hence trying to avoid doing it because of their fear of failure. According to Martin and Marsh (2003), students usually try to solve this conflict in one of two ways. They either work as hard as they can in order to avoid failure (overstrivers) or else they use counterproductive activities in order to protect themselves from failure (self-protectors). The latter group, instead of trying to avoid failure itself, try to escape from the implications that failure brings about, mainly those regarding their ability and self-worth. They usually try to do this either through self-handicapping or through defensive pessimism. Self-handicappers create obstructions in order to impede themselves from being successful such that they divert the cause of failure upon the created hurdle and not on their ability. For example, students may have opted not to do the tasks. In so doing, they seek to attribute their failure in the eyes of others as due to the fact that they did not even attempt to do the task. Therefore, their failure does not reflect on their ability. On the other hand, when using defensive pessimism, students lower their expectations such that they are easily achieved, thus protecting their self-worth. They also prepare themselves for the worst case scenarios such that if they fail, the downfall would not be so bad.

This means that the participating students' level of motivation can only be increased if firstly they develop a high level of self-efficacy. This is because all students enter the classroom with a baggage of different past experiences that have affected their self-efficacy level. However, if students are provided with specific goals of appropriate levels, immediate and effective feedback that is linked to their effort rather than their ability, and are rewarded for their progress rather than just their participation in an activity, they will receive the necessary cues from which they can self-assess their learning process and hence, their efficacy. This is because "motivation is enhanced when students perceive they are making progress in learning. In turn, as students work on tasks and become more skilful, they maintain a sense of self-efficacy for performing well" (Schunk, 1991, p. 208).

To conclude, the students' decision of engaging in the given tasks in order to prepare themselves for the next lesson (which is part of the flipped learning technique) depended on a lot of factors. The more the students attributed value to the given task, the higher their level of self-efficacy, the less they perceived the given tasks to be difficult, the more motivated they were and the greater their tendency to complete the assigned tasks.

## 4.4 Class Time

### 4.4.1 Identifying Students' Prior Knowledge and Misconceptions

Since the students gained a lot of new information from the videos and tasks they were assigned to do at home, I used to start off the lesson by posing a number of questions in order to prompt students to explain what they had learned at home. For example, in order to initiate the lesson regarding the structure of the atom the students were asked: 'What is an atom?', 'What are atoms made up of?', 'What is the mass and charge of a proton, neutron and electron?' and 'What is the charge of an atom? Why?' Most students seemed to like the way the lessons were introduced, stating that "in the beginning of the lesson you used to ask us questions about what we did and learned. I find that very useful because I tend to remember things more that way" (Student M, Focus group) and "that reminds me of what we had been doing and not feel like I'm on the moon, not knowing what we had been doing and saying" (Student L, Focus group).

Through this exercise, I was able to determine the students' prior knowledge, gauge the level of the students' understanding regarding the concepts learned at home and gather information about any difficulties or any misconceptions that they might have picked up along the way. For example, after the first lesson I wrote in my journal:

> The fact that all the students studied biology helped them understand what was happening in most of the experiments they carried out at home. They immediately realized that the process that occurs when someone sprays perfume in a closed room is called diffusion and they could easily identify the regions of low and high concentration within the same room. However, one particular student had the misconception that that when a drop of food colouring is placed in water diffusion does not occur. Instead, she thought that the process taking place is osmosis because according to her, diffusion is the movement of gas particles only and osmosis occurs whenever there is water involved. Osmosis is a concept that the students have learned in biology. Probably, they have learned it alongside diffusion and therefore some may be still unsure about the difference between osmosis and diffusion since both involve the movement of particles. At this point, I redirected the question of whether in this process diffusion or osmosis was occurring to the other students. Through prompting, peer tutoring and discussion (with many references to what they had discussed during the biology lesson) all the students finally arrived at a common, correct understanding of both diffusion and osmosis (Teacher's journal, 22 Nov 2017).

The topic 'Nature of Matter, Atomic Structure and Chemical Bonding' involved many new concepts and ideas that the students had never heard about. However, the students possessed schemata that helped them deal with the new information through a process of what Piaget refers to as assimilation (Posner, Strike, Hewson & Gertzog, 1982). For example, students knew that matter is made of particles. Hence, when at home they were given a video to watch regarding the structure of an atom, they could simply add the new information to their pre-existing knowledge. Contrastingly, at times, students possessed incorrect schemata which interfered with the assimilation process and gave rise to misconceptions (Posner et al., 1982). For example, the previously mentioned student regarded osmosis as being the movement of particles in water. When at home she dropped some food colouring in a glass of water and noticed that it was spreading, she assimilated this new piece of information to her previously acquired faulty schema and concluded that the observed process was called osmosis.

Encountered misconceptions were tackled in different ways as need be. In this case, it was her peers that acted as "Socratic tutors" (Posner et al., 1982, p. 226) and provided her with information that created conflict with her beliefs. Such information included the fact that osmosis is the movement of solvent (e.g. water) particles, that the movement of solvent particles occurs from a region of low concentration to a region of high concentration and that such movement occurs through a semi-permeable membrane. By comparing the acquired information to her experiment the mentioned student started to realize that there was a disequilibrium between her beliefs and her observations and as a result, she was no longer satisfied with her explanation. This is because in her experiment it was the ink particles, not the water particles, that were moving and the movement occurred from a region of high concentration to a region of low concentration without the involvement of a semi-permeable membrane. In fact, it was the feeling of discomfort with her previous explanation that eventually led the student to accommodate the newly presented concept.

As can be seen, it is very crucial that teachers tap into the students' prior knowledge before tackling a new concept. This is because "the acquisition of new content can be thwarted if it conflicts with students' pre-existing misinformation" (Campbell & Campbell, 2008, p.7). For example, in this case, if the student's misconception were not tackled, the student might have developed the idea that the meaning of diffusion differs from biology to chemistry, when in reality the same concept was just being looked at in two different subjects. In addition, the student might have also resorted to rote-learning by simply learning that whenever a drop of food colouring is dropped in water, the process of diffusion occurs, not because she has truly understood the concept but simply because the teacher said so. As a result, if the student is presented with a similar situation and she is asked to explain it, she would find it difficult to apply what she has learnt due to the lack of internalization of the said concept. In fact, it is also very important that students are not just told that their answer is incorrect but they must be shown why it is inaccurate for true understanding to take place. As von Glasersfeld (2012) states: "Only when students can be led to see as their own a problem in which their approach is manifestly inadequate will there be an incentive for them to change it" (p. 15).

I believe that, in an effort to combat students' misconceptions, it would be very beneficial if during the lesson preparation phase, the teacher, instead of focusing only on the preparation of activities that would lead students to the acquisition of knowledge, were to dedicate some time to read research papers in order to be aware of the misconceptions that students worldwide tend to experience regarding the concept being taught. Being thus prepared, learning tasks could be planned in a way such that misconceptions are either overcome or avoided in the first place. For example, in this study, being aware that many students tend to think that atoms may consist of actual rings surrounding the nucleus (Harrison & Treagust, 1996), I made it a point (by including it in my lesson plan) to stress the fact that these circles are only drawn to indicate the path taken by the electrons when they spin around the nucleus in a simplified model of the atom. In addition, I prepared a video in which the students could visualize a 3D atom with electrons spinning around the nucleus in a circular motion with no visible rings. As anticipated, this proved to be very useful, as I wrote down in my journal:

> The students understood both the power point and the video I sent them regarding the history of atomic theory and in fact they were able to explain in their own words the theories proposed by J.J. Thompson, Ernest Rutherford and Neil Bohr. The only misconception they had was that they thought that atoms consist of actual rings surrounding the nucleus and that electrons move on them. However, by watching the prepared video, the students quickly understood the proposed model (Teacher's journal, 29 Nov, 2017).

Whilst keeping all the above in mind, one would be mistaken to think that all of the students' prior knowledge is infested with misconceptions which interfere with their learning. On the contrary, just as Ausubel theorized, if correct, "prior knowledge facilitates learning by creating mental hooks that serve to anchor instructional concepts" (as cited in Campbell & Campbell, 2008, p.7). As a matter of fact, learning as the passage way of moving from the known to the unknown was truly encouraged during this study. For example, in an attempt to explain why pollen particles were seen to move under the microscope when suspended in water, students were firstly encouraged to state the seven vital functions in order to determine whether pollen grains are alive or not. Then, they were prompted to go through the kinetic theory and use the previously learnt concepts in order to explain their observation. This was illustrated in my journal when I wrote:

> When discussing the fact that Robert Brown saw the pollen grains jiggling about in water under the microscope, I was very pleased with the fact that one student exclaimed that pollen grains are not alive since they don't have the 7 vital functions like respiration, reproduction and nutrition and therefore they could not have been moving out of their own free will. One student then stated that this could have happened due to something related to the presence of water. When told that she was on the right track she continued to explain through prompting that the water is made of particles and that since water is a liquid its particles are able to move from one place to another. In doing so, they bump into the pollen particles making them move. At that moment I was very pleased that this student was able to explain the observations made by Robert Brown with the concepts she learned in the previous chapter showing her true and deep understanding of things. Through her explanation, other students could then explain why dust particles are seen to move on their own in a ray of light and why unburnt carbon particles can be seen to move in a smoke cell (Teacher's journal, 27 Nov 2017).

Therefore, one can conclude that, when using the flipped learning technique, where students are encouraged to gain certain knowledge at home,

> engaging students' preexisting knowledge or misperceptions offers teachers one way to informally diagnose their students' baseline. This can then serve as the critical first step in the learning cycle of the classroom. By meeting students where they are, teachers can make informed, strategic decisions about the content to be taught (Campbell & Campbell, 2012, p. 12).

### 4.4.2 Building a Culture of Inquiry

Students participating in this study have passed through an educational system where they have been "schooled to become masters at answering questions and to remain novices at asking them" (Dillon, 1988, p.115). In fact, as explained in Section 4.3.2.2, when they were asked to watch a video and answer some follow-up questions, students used to copy the answers word for word from the video's subtitles and they used to hesitate when asked to elaborate and explain what they had learnt in their own words. One other reason for this observation, (other than that already explained), could be the fact that students are not used to being asked why. On the contrary, they are used to teachers asking them factual questions who are satisfied once given the correct answer. Fortunately, the use of the flipped learning technique enabled me to free some class time from the delivery of the required content (since students gained most of it at home) and I had time to instil in students a spark that probed their innate sense of inquiry.

In order to do this, I firstly wanted to show the students that inquiry lies at the heart of all scientific discoveries and it is thanks to our ancestors' curious nature that led to the formulation of theories which we nowadays take for granted. Thereby, I started off the topic by going through the history of the atomic theory. Through this activity, the students were able to realize that it was the fact that people always wanted to know what things are made up of that initiated the development of the atomic theory. In addition, they became aware, that what we know about the atom today was not formulated by one person all at once. On the contrary, it took around 2,400 years for the establishment of the atomic theory we accept nowadays. Throughout these years, people proposed ideas based on their thoughts and experiments. They challenged each other with the aim of providing a better explanation. As a result, some ideas were abandoned immediately whilst others were accepted for a short period of time until someone else provided a better one. This is how science works.

The students were very captivated by the story of how philosophers and scientists kept chasing their curiosities, asking questions and seeking answers to fulfil their inquisitiveness, stating that they "enjoyed learning history about the atomic theory" (Student A, Reflective journal, 22 Nov, 2017). The intentions behind this activity seem to have been recognized by the students as shown in my journal:

> The students said that they did not previously know that what stuff is made of is actually a theory, developed by many scientists. One student even mentioned that being a theory, something can be discovered in the future that will enable it to develop even further. Moreover, they were fascinated by the fact that this theory started to develop at around 440BC, at an age when they did not have any apparatus or machines to do experiments with. Rather, it was one thoughtful philosopher that set the ball rolling. They were also fascinated by the fact that this theory continued to develop by John Dalton

> more than 1000 years after Aristotle. Most of the students commented on how they continued to watch the video till the very end even though they were instructed to watch just the first part, showing the interest and enthusiasm the students had (Teacher's journal, 22 Nov, 2017).

During this study, it was noticed that if students are encouraged and given the right opportunity they are able to raise very thoughtful questions that enhance their learning. This is illustrated in the anecdote written in my journal.

> When the students were presented with a new experiment, where two pieces of cotton wool (one dipped in ammonia solution and one in concentrated hydrochloric acid) are placed at the opposite ends of a long glass tube, they could easily apply what they had learned beforehand to this new situation. In fact, when asked what they think would happen, they immediately mentioned that the particles of the two gases would diffuse inside the tube and eventually meet. When asked to indicate the approximate place where they think the two gases will meet, one of the students immediately said that they will meet in the centre of the tube without further thinking. Most of the students agreed. However, one particular student seemed to disagree saying that "it depends". When asked to explain, this student asked me which of the two gases will diffuse faster stating that not all gases diffuse at the same speed since this depends on their densities. At this moment, the other students' blocked views were unveiled and it was at this particular moment that they truly understood the whole concept (Teacher's journal, 22 Nov, 2017).

As can be seen, when asked to predict the result of the experiment, this particular student was able to immerse himself in deep thought and link many concepts together. He was able to retrieve the fact that gases have different densities from his long-term-memory. Then, he reasoned out that this would affect the rate of diffusion of the given gases. When he finally identified a gap in his knowledge, that is, he did not know which of the two given gases had the largest density, he was stimulated to ask me the key question which led him to extend his knowledge as well as solve the given problem. In addition, the fact that he voiced his thoughts and questions proved to be beneficial not only to him but also to the rest of his class mates. This is because, it was only after he shared the ideas and queries that were crossing his mind that the other students comprehended the experiment's underlying concepts.

At times, I instigated the students to ask questions by presenting them with anomalies that made them question what at first seemed to be factual. For example:

> Today, I started off the lesson by asking the students what the mass number and atomic number of chlorine are. Once they told me that the R.A.M. is 35.5

> and the atomic number is 17, I asked them to deduce how many protons, neutrons and electrons chlorine has. When one student answered that it has 18.5 neutrons, another student quickly asked whether it is possible that chlorine has half a neutron. Taking a look at the periodic table they immediately noticed that all the mass numbers of the other elements were in decimals and that if one had to deduce the number of neutrons of each one, they would all end up with fractions of neutrons. At this point the level of students' interest was very high. They were all engaged, trying to think how this could be so. The students' motivation increased even further when I answered by telling them than in reality chlorine with a mass number of 35.5 does not exist. Instead two types of chlorine exist; Cl-35 and Cl-37. One student asked how come chlorine with a mass number of 35.5 does not exist when it is written in the periodic table. Another student asked whether the 35.5 is an average of the two. However, this option was quickly dismissed by another student who stated that it could not be so, since if an average was taken the answer would have been 36 not 35.5. At this point, I had to intervene stating that the 35.5 is in fact an average between the two. However, it is not worked out the same way as in maths. This led to a discussion about isotopes and the method of how the relative atomic mass of elements is determined (Teacher's journal, 6 Dec, 2017).

Sometimes, when the concepts being studied are abstract and not so much related to everyday life, it is difficult for the students to come up with their own questions. Hence, it would be the teacher's job to set the correct scene and ask the right questions which would prompt students to engage in deep thinking strategies. "Such questions can help learners initiate a process of hypothesizing, predicting, thought experimenting, and explaining, thereby leading to a cascade of generative activity" (Chin, 2002, p.60).

But why are students finding it so difficult to inquire and ask questions? Suzić, (2017) suggests that this could be due to the fact that when children go to school, they find themselves within an environment where knowledge is fragmented into subjects and where each subject has an overloaded curriculum that teachers need to pass on to their students. Time to do so is limited and hence students are expected to sit quietly and listen to their teacher explain. Every now and then, the teacher asks a question and the students answer. There is no time for interruptions or for students' questions. Good grades are awarded to those who are good at memorizing facts and regurgitating everything the teacher has said. Students are trained on what they are supposed to say, do and think. If students do not follow the given instructions, they are punished and obtain low grades. At some point in time, when students are still in elementary school, the place where they had firstly entered with so much enthusiasm and thirst for learning, the message that thinking is not for them passes through and all of a sudden they stop asking questions. Learning becomes boring and school becomes a burden.

If we had to go back in time when schooling was initiated, way before the structures made of mortar and concrete were built, learning was all about asking the right questions to gain a deeper insight of things. In fact, this is still well known as the Socratic Method, named after the great philosopher who used questioning to help his student reflect, think and analyse what justice truly is (Tienken, Goldberg & Dirocco, 2009). Unfortunately, somewhere along the line, the focus of education seems to have deviated from the acquiring of inquisitive skills to the gaining and memorisation of facts. However, the need to re-shift the focus back to inquiry is being felt.

In fact, one of the aims of education as outlined by the Maltese National Curriculum Framework (NCF) (2012) is "to acquire the knowledge, skills, values and attitudes that make them capable of sustaining their life chances in the changing world of employment" (Ministry of Education and Employment, 2012, p. 33). This means that teachers are required to equip students with skills that they think would make them employable in jobs that have not yet been created. Due to the rapid advancements in technology, the capability of cramming information and memorising facts is surely not going to be the skill that will make them competitive individuals within the 21st century's world of work. On the contrary, skills such as critical thinking, flexibility, problem solving and innovation are going to be the ones that will make them successful (Saavedra & Opfer, 2012). During this study, due to the use of the flipped learning technique, I felt that I had more time to help the students acquire some of these skills.

### 4.4.3 Encouraging Peer Tutoring

The flipped learning approach freed up class time that could be used for student centred activities such as collaborative learning. In fact, during the lesson, I used to encourage the students to pair up and work together in order to complete an assigned task. Student cooperation was highly promoted during this study since research shows that this "results in higher achievement, greater retention, more positive feelings by the students about each other and the subject matter, and stronger academic self esteem" (Johnson & Johnson, 2008, p.29). Since the tasks mostly involved the working of calculations, the drawing of atoms, ionic and covalent compounds as well as the writing of formulae, all of which have a definite answer, interaction served as a means of how students could support and peer tutor each other rather than to solve inquiry-based problems together. In this section, students' experience of collaborative learning as part of this study will be presented and discussed.

Twelve of the participating students declared that they "enjoyed the group work" (Student J, Reflective journal, 8 Jan, 2018). Student E declared that she enjoyed working in pairs due to the fact that "sometimes there are things that you know well for example, but the others do not and they may know things that you don't" (Student E, Focus Group). This argument was supported by both Student N who replied "yes, we help each other out" (Student N, Focus group) and Student L who claimed that "when we have a problem and for example something is very difficult to work out, we used to work it out together so that for example I remember how part of it should be worked out while my friend remembers how to work another part" (Student L, Focus group).

This is exactly what peer tutoring is all about. Just as the students aptly explained, when working with a class mate, students had the opportunity to explain things to each other. On the one hand, peer tutors gained from this activity since "the best way to really develop one's understanding of an area is to teach it to some-one else" (Beasley, 1997, p.21). On the other hand, tutees benefited as well since they were able to get a simplified version of the teacher's explanation. More importantly, through peer tutoring students were encouraged to take a more active role, to experience different teaching styles, to look at concepts from a different point of view and to have more student-student face-to-face interactions. Peer tutoring was a crucial step to help "transform students from being passive, 'teacher' dependent, uncritical recipients and reproducers of information into engaged, questioning, reflective and autonomous learners" (Gardiner, 1996 as cited in Beasely, 1997, p.21).

The benefits of peer tutoring are underpinned by Lev Vygotsky's social constructivist theory of learning. Vygotsky believed that one can only develop his/her language, thoughts and reasoning through social interaction and collaboration with others. This is because, different people belong to different communities and hence endorse different cultures. Through cooperation with each other, people are able to influence each other and hence contribute to each other's intellectual growth. One of Vygotsky's well known theories is the one regarding the Zone of Proximal Development (ZPD). He explains that there are tasks which students are able to complete without the assistance of others. On the other hand, there are tasks which are beyond the students' capabilities. Within the area between these two domains, better known as the ZPD, lie the tasks which students are able to master with the support and guidance of adults or more knowledgeable peers. Therefore, as can be seen, social interaction is crucial within the classroom because otherwise there are concepts and skills which students are not able to grasp without the help of others (Santrock, 2008).

Another reason given by students as to why they enjoyed working in pairs was due to the fact that "we had teamwork with a friend" (Student H, Reflective journal, 4 Dec, 2017). Even during the focus group, the students stated that they enjoyed working in groups "because we could pick our friends" (Student F, Focus group). When probed in order to explain why, one particular student said that "when you have a difficulty for example, you can ask it to your friends" (Student N, Focus group), to which Student M added "you're not afraid to ask them" (Student M, Focus Group). Student L continued to explain that "I don't mind asking the teacher questions especially since you're ok and you would never humiliate me. Even when I don't understand something you always explain it to me. But sometimes there tend to be teachers that humiliate you or they don't explain things well so I prefer to ask my friends" (Student L, Focus group).

During the organization of pair-work activities, I was faced with a choice of either selecting the pairs of students who were to work with each other or else allow the students to work with anyone they liked. Literature tends to favour the setting up of heterogeneous groups made up of members with different learning styles, achievement levels, gender and race amongst other categories. This is because such groupings "encourage the acceptance of diverse styles and points of view, promote achievement in mixed ability classes, and produce benefits in socio-emotional domains" (Mitchell, Rosemary, Bramwell, Solnosky & Lilly, 2004, p. 20). Taking the group of students participating in this study, the criteria upon which groupings could have been made were gender, learning styles and achievement levels. When taking these factors into consideration, it was decided that since I only had the chance to get to know the students for two months prior to the study, it was far too early to determine their exact learning style and achievement level. In addition, grouping the students based on their gender did not make sense since the class consisted of just 4 boys and 11 girls. Hence, it was decided that the students would be given the chance to choose for themselves the partner they wished to work with. When given this choice the students decided to work alongside their friends.

On the one hand, "there is evidence that students who know and like each other benefit most from working together as they tend to accept more responsibility for their learning and are more motivated to achieve their goals than students who are not friends" (Gilles & Boyle, 2010, p. 235-236). In addition, students may opt to work with their friends in order to feel socially accepted, protect their peer group status as well as safeguard their self-worthiness as indicated by the students participating in this study. During the focus group, students indicated that there was a time (not necessarily during the chemistry lesson), when they felt "humiliated" when they asked a question to their teacher in front of their peers. This could have happened due to one of two reasons, that is, either due to the negative classroom climate present or due to the acceptable norms that are set by the students themselves. In the former scenario, the students may have been present in a classroom where questions made by the students were not valued enough and perhaps dismissed. Or the teacher could have passed comments which made the students feel that they are not good enough. In the latter scenario, students may have felt uncomfortable asking questions to their teacher since amongst them there is an unwritten norm that whoever does so is considered to be uncool or dumb (Newman & Schwager, 1993).

Furthermore, as pinpointed by the students themselves, sometimes teachers make use of a vocabulary which is not readily understood by the students themselves. Working in pairs enabled students to translate what the teacher said in “reduced, or “simplified” form… typically characterized by shorter, syntactically less complex utterances, higher frequency vocabulary items, and the avoidance of idiomatic expressions. It also tends to be delivered at a slower rate than normal adult speech” (Long & Porter, 1985, p.113) making scientific concepts easier to be understood.

However, it was noticed that even though the students enjoyed working with their friends, this was not always a wise choice. As Student E pointed out “sometimes we would be doing something and then we end up doing something else” (Student E, Focus group). Other students admitted that the same thing used to occur in their case as well stating that “yes, that’s what used to happen to me especially when I used to be with my friend” (Student F, Focus group). Other students however claimed that they do not consider this a problem because “it used to be something brief. Then I used to continue” (Student L, Focus group). The latter, seemed to be a very self-disciplined student since she continued explaining that “if I start for example deviating from my work or I have a tendency to do so whilst working with someone, I don’t stay with them during group work” (Student L, Focus group). She continued to add that “it’s true that you tend to be a bit sad if you change partners, but we’re in chemistry class. We have to learn and it’s for our own good after all, not for the teacher or anyone else” (Student L, Focus group). Student M seemed to agree adding that “plus you will get to know other people” (Student M, Focus group).

As can be seen, if students get to work with their friends, (whether the flipped learning technique is used or not), they may not spend all the allocated time on task but may revert to socialising. For some this may be distracting since it would be difficult for them to get back on task. For those who are more self-disciplined however and who tend to regain back their attention quite quickly this may not be a problem at all. Therefore, I think it would be beneficial that the teacher goes round the groups checking their progress and asking them work-related questions to keep them on task. In addition, changing the groups from time-to-time would prevent the students from getting too comfortable with each other. Furthermore, just like the students indicated, working alongside students who are not considered to be very close friends may be beneficial since they may stimulate new friendships. In addition, it is important that students learn to work in a team and with people that they barely know or are not very close to. This is because the ability to work efficiently in a group is one of the factors that affects employability (Chapman, Meuter, Toy & Wright, 2006).

Another pitfall of self-selected groups cropped up during the focus group when students started explaining how they used to collaborate together. For instance one student explained that whilst working together, “we, for example, if we did not understand something we used to look at it together, you know, we share hints and tips and compare answers with each other. And for example sometimes when I did not understand something very well, I used to try it on my own and then compare the answer to that obtained by my friend who would have understood well and I’ll check whether it’s good… I felt I understood better that way” (Student L, Focus group). However, another student explained that they used to work in a slightly different way since “we used to check our answers together. Then, if we don’t agree we used to ask you” (Student A, Focus group).

Whilst going round the students in class, I also observed how students made use of different methods in order to work together. In fact, I reported in my journal:

> Whilst going round the groups, I noticed that some students first worked out the answer on their own and then they compared their answers with each other. If they obtained the same answer they simply went on to work out the next question. If not, they started discussing and explaining how they worked it out to each other until together they identified the mistake one of them had previously did. Another group of students worked in a different way. They first

> read the question individually, then they discussed it and they finally wrote down the answer which they had previously agreed upon. Another group of students, were still unsure how to determine the number of electrons, protons and neutrons. Therefore, they first confirmed what they had understood with me. Once I told them they had explained the concepts involved correctly, they felt assured that they were on the right track and so they continued working the exercise on their own. Going round, students started showing me their work ensuring that they were working out the answers correctly. However, I noticed that a particular pair of students, when encountering a difficulty, instead of discussing it with each other and attempting to resolve it by themselves, they immediately asked me for help. Although I tried to encourage them to firstly try to solve the problem on their own, they kept asking for my help very frequently (Teacher's journal, 4 Dec, 2017).

Reflecting back on this incident, I have realized that when students are allowed to choose with whom to work with, not only do they opt to work with whom they know best, but there is a tendency that they group up with peers of the same achievement level as theirs. As noticed, although groups made up of high or average achievement level students may experience difficulties while working the given tasks, they are able to discuss problems together, peer tutor each other and hence resolve their own problems, most of the time. However, the same thing certainly does not happen in groups where students are both of low ability. This is because "low-achieving students tend to have lower rates of interaction and do not take advantage of leadership opportunities" (Mitchell et al., 2004, p. 21). In addition, they tend to experience the same difficulties and hence may not be able to peer tutor each other. Thereby, although they do try to work together they would need constant help from their teacher. This means that the faster the teacher becomes familiar with the students' different abilities, the better so that s/he would be able to take this into consideration when organising collaborative work.

In another instance, one particular student took advantage of having the opportunity to work with her friend and she was caught copying down her answers instead of collaborating with her and ask for help if need be. This was illustrated in my journal as follows:

> When the students were given an exercise in order to work the R.A.M of several isotopes, most of them found the exercise quite plain sailing. However, whilst going round the students I noticed that one particular student

> was copying the answers from her friend who was sitting next to her. When I asked her why she was doing so she said that she was not completely sure how to work them out. I hence encouraged her friend to explain to her how she could find the R.A.M. of the given isotopes so that she would be able to work them out on her own. I also tried to explain that copying down answers only leads to a short-term solution to problems and that if she truly wants to learn, she should ask for help since her friend or if need be myself, would surely help her overcome obstacles that were clouding her thoughts (Teacher's journal, 6 Dec, 2017).

This shows that if teachers want students to be effective tutors, they should firstly be trained such that they realize that their job is "not to "give answers" to students. Rather, their role [is] firstly, to help develop the students' thinking and understanding of the course content, tasks, and lecturers' expectations, and secondly, to help students develop appropriate strategies for dealing effectively with these" (Beasley, 1997, p.23).

Peer tutoring was certainly not enjoyed by everyone. In fact only one student strongly agreed, three agreed while four slightly agreed with the statement 'I enjoyed explaining what I learned to my classmates during the lesson'. One particular student stated that "I prefer my own way of explanation than others'" (Student F, Reflective journal, 27 Nov, 2017). Another student declared that "it depends on the difficulty level of the topic" (Student E, Focus group). She explained that "I prefer to work out ionic bonding, covalent bonding and similar things on my own" (Student L, Focus group). "It's because they involve a lot of writing and practice and you have to be careful that you don't forget anything such as a dot or a cross. So I prefer to work alone. I tend to concentrate more and be able to check whether I completed everything" (Student L, Focus group). Another student mentioned the fact that group work is not always enjoyable since "when there is a lot of noise I'm not able to concentrate" (Student O, Focus group).

These comments may have come from high-achieving students who were grouped with less-achieving students. Being of a high ability, they may have taken the role of explaining concepts to their peers and thus they might feel that they have not benefitted from this pair work activity. On the contrary, they might perceive their peers as a burden since they might have held them back by their constant questions and problems. They may presume that if they had to complete the same exercise on their own, they would have completed it in a shorter amount of time and even made fewer mistakes since they would have had more time to concentrate on their work (Robinson, 1990). In a study carried out by Aquilina (2015), similar results were obtained. In her study, Aquilina allowed the students to choose with whom they wished to work with in order to complete an inquiry-based task. It was found that high-achieving students did not wish to work together with low-achieving students since they felt that the latter would not be able to contribute in the planning and accomplishment of the assigned task. Instead, they preferred to work with students of similar abilities as theirs, stating that they felt more comfortable working alongside someone whom they believed to be capable of giving a helping hand.

Therefore as one might notice, pair work and peer tutoring both have their pros and cons and a teacher has to consider whether the benefits of these techniques outweigh the drawbacks before utilizing them in the classroom.

### 4.4.4 Supporting Students

Although peer tutoring was encouraged as much as possible, my support and guidance was still needed. The use of the flipped learning approach enabled me to free some classroom time in order to support the students as need be. For instance, sometimes students needed help in organizing their thoughts. In fact they stated that "at first I was a bit confused but then my teacher came and explained them to me" (Student N, Reflective journal, 8 Jan, 2018). During this particular lesson, the students were asked to draw an ionic compound for the first time and

> I realized that not all of the students were very confident in working them out and hence obtain correct answers. Some students were still feeling a bit uneasy since they did not know from where to begin. After providing the students with a set of steps which they could easily follow, they were able to complete the required task successfully (Teacher's journal, 8, Jan, 2018).

Other students sometimes needed to be reminded of the concepts they learnt since they kept “forgetting the rules” (Student G, Reflective journal, 22 Jan, 2018). For instance,

> going round, I noticed that two students did not grasp the method of how to write the formulae of compounds well. They seemed to have forgotten how to apply the rules they had just learnt. Hence, I went near them and reminded them of certain aspects such as what the Roman number in a compound’s name means, how to determine the valencies of certain transition metals such as silver and those of the polyatomic ions and when they should make use of the brackets. Although they still need some practice and some time to assimilate what they have learned during this lesson, they did manage to work out most of the formulae correctly by the end of the lesson (Teacher’s journal, 22 Jan, 2018).

At times, students needed someone to draw their attention to certain mistakes that they were unknowingly making. For example,

> another mistake that some students kept repeating was, that whilst drawing the outer shell electrons they first drew all the electrons the atoms originally had. Then, they drew the electrons that were being shared, with the consequence that they were forgetting to rub off the electrons that the atoms were sharing. As a result, it seemed that the atoms could accommodate more than 8 electrons in their outer shell whilst bonding. (Teacher’s journal, 15 Jan, 2018).

In other circumstances, students just needed some prompting in order to be able to reach the required goal. For example,

> whilst drawing the given molecules, some students did not take into consideration the formula of the compound. For example, when trying to draw the molecule of water, they did not realize that since its formula is $H_2O$ they have to draw two hydrogen atoms and one oxygen atom. Instead, they drew one hydrogen atom and one oxygen atom. After prompting the students by asking them questions such as ‘What is the formula of water?’ and ‘What does the 2 in $H_2O$ mean?’, they were able to draw the given molecules correctly (Teacher’s journal, 15 Jan, 2018).

There were moments when, students just needed reassurance that they were on the right track. For example, after assigning students a task where they had to draw different atoms, it was noticed that

> [a] group of students, were still unsure how to determine the number of electrons, protons and neutrons. Therefore, they first confirmed what they

> had understood with me. Once I told them they had explained the concepts involved correctly, they felt assured that they were on the right track and so they continued working the exercise on their own (Teacher's journal, 4 Dec, 2017).

This made the students feel "confident because my miss [sic] is nice and very helpful and when you don't know something she always response [sic] you" (Student N, Reflective journal, 4 Dec, 2017). In addition, during some lessons students were not "in the mood for work because I was tired" (Student L, Reflective journal, 6 Dec, 2017) or "sleepy" (Student N, Reflective journal, 29 Nov, 2017) and hence since their attention seemed to be going in and out of focus, they needed someone to give them more individual attention. In other instances, students needed some encouragement because they were on the verge of giving up and were feeling "depressed but then my teacher told me to calm down and [I] repeated them" (Student N, Reflective journal, 10 Jan, 2018).

In a traditional classroom, teachers usually introduce the new material in class and then assign students homework based on the newly-gained knowledge. Whilst completing their work at home, students sometimes encounter difficulties but have no one to turn to and ask for help. Hence, they end up going to school with incomplete tasks. Some tend to struggle so much trying to translate what they have learnt in class into useful material that can be used in their homework, that they simply get disheartened and give up. But this is when students need their teacher the most. Teachers are not needed to transmit information to their students. They are needed at the very moment when students feel that they are stuck and cannot complete a task on their own. They are needed when students require a word of encouragement that would boost their confidence and thus, help them move forward. They are needed to provide the necessary scaffolding students need to reach their targets (Bergmann & Sams, 2012). Due to the use of the flipped learning technique, this was made possible.

Whilst in class, students were able to revise what they learned at home, resolving any difficulties or misconceptions that they might have had. They continued to build on what they had learned through a process of inquiry. Finally, time was allocated such that the students could put what they have learnt into practice. During this time I used to go round the students, observe them working and hence determine what kind of support each and every student needed to be able to reach his/her potential. I was able to give the students the necessary prompts that could keep them going, remind students of certain concepts that they may have forgotten or draw the attention of students to certain mistakes encouraging them to revise their work. My time was mostly spent next to students who needed me the most, thereby promoting educational equity. In fact, thirteen of the fourteen participating students strongly agreed – while one agreed - with the statement 'The teacher helped me whenever I had a difficulty'.

### 4.4.5 Assessing Students and giving them Feedback

The use of the flipped learning technique also enabled me to assess the students more frequently and provide them with better feedback. All the tasks mentioned in Sections 4.4.3 and 4.4.4 formed part of a set of activities which were aimed at giving both the students and the teacher an insight of whether the targeted aims were reached or not. As one could notice, most of the tasks involved written work. It was made sure that these exercises consisted of graded questions such that all of the students were able to answer the first few questions thereby boosting their confidence. Later on, more challenging questions were given such that high ability students were able to complete most of them on their own whilst average and low ability students managed to complete them with the help of their peers or mine as shown:

> Question 4 was the most difficult question and only those students who had truly understood the concepts discussed during the previous lessons answered this question correctly. In this question, the students were given three atoms A, B and C and they were given the number of electrons found in each one. Then they were asked to determine the formula of the compound formed if several pairs of each these elements combined together and in doing so what type of bond formed. The students who felt very confident working questions related to ionic and covalent bonding, immediately looked at the periodic table and determined what each element was and completed the rest of the question successfully. However, those students who were still uncertain of certain concepts, found this question much more difficult. At this point the

> students who completed it successfully took the opportunity to explain how this question had to be worked out (Teacher's journal, 17 Jan, 2018).

Since the topic 'Nature of Matter, Atomic Structure and Chemical Bonding' consists of a lot of facts which students have to remember, their recall ability as well as their level of understanding of facts was tested through a number of direct, verbal questions as shown below:

> Today was the second lesson we spent discussing the atomic structure. Since all the concepts regarding the atomic structure were elicited during the last lesson, I decided to assess the students' knowledge regarding this concept. I therefore asked the students:
>
> i) to identify the mass number and atomic number of different elements;
> ii) to determine how many protons, neutrons and electrons different elements have;
> iii) what the different parts of the atom are called;
> iv) where the sub-atomic particles are found in atoms;
> v) how to draw the structure of an atom; and
> vi) how to write the electronic configuration of atoms.
>
> Most of the students remembered and understood the above concepts very well. Only three students were a bit uncertain of how to determine the number of sub-atomic particles in an atom and how to distribute the electrons in shells. However, after working out a couple of examples with them they quickly remembered how (Teacher's journal, 4 Dec, 2017).

PowerPoint games were also used as a means of formative assessment. For example, during one particular lesson, I wanted to check whether the students had truly understood what isotopes are. Hence, I used a PowerPoint presentation in order to show the students pictures of elements. For each set of pictures shown, students had to state whether they depicted isotopes or not and give a reason why. As written in my journal:

> Through the PowerPoint game I was able to see that the students truly understood what isotopes are. They were able to determine which number represents the atomic number of the given atoms and hence decide whether they were isotopes of each other or not giving reasons for their answer (Teacher's journal, 6 Dec, 2017).

Quizzes were also used to determine the level of understanding of the students. In fact, once

> I showed the students an animation showing the formation of an ionic bond. During these animations students stated that they understood more clearly how ionic bonds form. This seemed to be true since in the follow up quiz which they carried out in groups, they managed to work out the questions correctly as well as back up their answers with correct explanations (Teacher's journal, 8 Jan 2018).

Students completed other assessment tasks in groups. For instance, once they teamed up in groups of four and each team was given a sheet with the same set of statements regarding ionic bonding as shown in Appendix 6. Within each group, students had to discuss and hence determine, giving reasons, whether each of the given statements was true or false. After all the groups completed this exercise, the discussion that occurred within the groups was then extended to the whole class. This was illustrated in my journal as follows:

> This exercise was followed by a group work activity, where students had to stay in groups of 4 and discuss whether the given statements about ionic bonding are true or false, explaining why. Once the students discussed the statements within their groups, a whole class discussion was carried out. One thing I noticed was that some students did not understand the statements well since they missed some important words that changed the meaning of the whole sentence. Therefore, these words had to be pinpointed and explained first before they were able to comment on them. An example of such a statement is: 'A sodium ion is only bonded to the chloride ion it donated its electron to.' Some students did not take the word 'only' into consideration and so argued that the statement is true. This is because, according to them, if a sodium atom donates an electron to a chlorine atom, they would both become charged, their outer shell would be full and so they would bond. Something which caught my attention during this exercise was, that many students thought that an ionic bond simply forms when a metal atom donates its outer shell electrons to a non-metal atom. They placed the emphasis on the formation of an ionic bond on the transfer of electrons rather than on the attraction between a positive and a negative ion. It was only after several prompts that one student mentioned the attractive force that is present between the ions that form. After discussing the 5$^{th}$ statement, I realized that the students' misconceptions had been cleared because they could well explain the statements that followed using arguments that had been previously discussed (Teacher's journal, 10 Jan, 2018).

As shown, whenever I detected a misconception or a difficulty, this was tackled accordingly. Feedback was provided mostly orally such that the students knew in which areas they were doing well and in which areas they needed to exert more effort, practice and study. In fact ten of the participating students strongly agreed while four agreed with the statement 'The teacher gave me feedback on my work and so I knew what I was doing right or what needed improvement'. In addition, when the study came to an end three students strongly agreed, eight agreed while three slightly agreed that they 'feel confident working out questions related to this topic on my own'. Students liked the fact that they were given these formative assessment tasks, firstly because otherwise "if you don't understand something for example, the teacher would not be able to know" (Student E, Focus group). In addition, "if we had any mistakes or difficulties you could have told us at school and then we'll be careful and get used to them at home" (Student L, Focus group). Due to the feedback given they "got used to prevent doing certain mistakes" (Student L, Focus group). Moreover, since "we had to revise our work" (Student A, Reflective journal, 29 Nov, 2017), students had the chance to reflect on their performance and this led some students to realize that "I should study more so I could understand more" (Student N, Reflective journal, 22 Jan, 2018).

Even though teachers may have very detailed and well-planned lesson plans which incorporate in them different learning pedagogies that will enable them to reach out to every student in their classroom, students rarely reach every learning objective. In addition, during the lesson, they may gain understandings which differ from those intended. Hence, assessment plays a crucial role within the classroom as this would enable both the teacher and the learner to identify up to what degree the activities carried out in the classroom resulted in learning (Wiliam, 2011). During this study students were assessed from the moment they entered the classroom till it was time for them to leave. This is because, as explained in Section 4.4.1, at the beginning of the lesson students were asked a number of questions so as to determine what concepts they had learned at home and whether they had gained any misconceptions in the process. After information was elicited from the students, tasks were assigned such that they would be able to put what they had learned into practice. Most of the tasks were carried out in groups as explained in Section 4.4.3.

Information regarding students' mastery of concepts was gained through different methods such as verbal questions and answers, quizzes, PowerPoint games, written exercises and group work. This enabled me to assess a broad range of skills.

For example, with the use of the verbal questions, I was able to assess students' ability to recall factual information. Through the quizzes and PowerPoint games I was able to determine whether they had comprehended certain concepts. The written exercises helped in determining whether the students were able to apply the concepts they had learnt. Finally, the group work exercise where students were provided with a sheet of statements and they had to determine whether each statement was true or false giving reasons tested the students' analytical and evaluation skills.

The type of assessments that were used are of the formative type since they were "used to shape and improve the student's competence" (Sadler, 1989, p. 120). In fact, every assessment task taken by the students was accompanied by verbal, just-in-time feedback. This is because whilst the students used to be working on a given assessment task, I used to go round, observing them work and discuss. That way, I was able to identify "the gap" (Ramaprasad, 1983, p.4) between the students' current performance and the desired one. Having done so, I would engage with the students in a dialogue such that information regarding their performance is not simply transmitted. On the contrary, through a discussion, I was able to "help students to develop their understanding of expectations and standards, to check out and correct misunderstandings and to get an immediate response to difficulties" (Nicol & Macfarlane-Dick, 2006, p. 210). This is what made the feedback given effective. Usually, when students are given a piece of work and they complete it at home, teachers tend to collect it (due to the lack of time to do a class correction) and hence attribute a mark and perhaps a comment at the end of the task. Doing so does not ensure that the students have read the written feedback. In addition, even if they do, one cannot be sure whether they have truly understood the given information regarding their performance and can subsequently translate it into a way of how they can tweak and adjust their work to improve their performance. By engaging in a discussion with the students, I was able to clarify what the expected goals are, show the students exemplars so that they would be able to compare their work with that shown and hence understand what is expected and in what way they can improve (Nicol & Macfarlane-Dick, 2006).

## 4.5 Are Students Ready to take Responsibility for their own Learning?

Being responsible for one's own learning means being self-driven, being able to identify one's strengths and weaknesses, being able to choose the most effective learning strategy which would lead to success, being able to monitor one's own progress and being able to learn how to learn. Grow (1991), identified four stages in which students may be located in their journey towards self-directed learning. These stages are summarized in Table 2:

*Table 2: The stages towards a self-directed model of learning (Grow, 1991, p.129)*

| Stage | Student | Teacher | Examples |
|---|---|---|---|
| Stage 1 | Dependent | Authority Coach | Coaching with immediate feedback. Drill. Informational lecture. Overcoming deficiencies and resistence. |
| Stage 2 | Interested | Motivator, guide | Inspiring lecture plus guided discussion. Goal-setting and learning strategies. |
| Stage 3 | Involved | Facilitator | Discussion facilitated by teacher who participates as equal. Seminar. Group projects. |
| Stage 4 | Self-directed | Consultant, delegator | Internship, dissertation, individual work or self-directed study-group. |

Students who are in stage 1 are very teacher dependent. They visualize the teacher as an expert and hence rely on him/her in order to coach them and tell them what they need to do in order to learn. They prefer to learn through the passive method where knowledge is simply transmitted to them in order to memorize it and hence regurgitate it in exams. Students within the second stage of their journey, tend to be more open to try and engage in student-centred methods of learning especially if they are able to recognise the purpose behind the technique. Students show more signs of enthusiasm, motivation and willingness to learn. Stage 3 learners are not only motivated to learn but they are equipped with the necessary skills such as that they are able to explore a subject partly on their own and partly under the guidance of a more knowledgeable other. They tend to show more traits of confidence, have a greater sense of direction and are able to collaborate as well as learn from others. Students that have reached the final stage of their journey are able to take more responsibility and ownership of their learning. They view themselves as experts in setting their own goals and constructing strategies in order to be able to reach them. In addition they are able to self-evaluate and determine ways in which they can improve (Grow, 1991).

As described in Section 4.3.2, the students participating in this study were very motivated to learn. In fact eight of the participating students strongly agreed, four agreed while two slightly agreed that they ‘enjoyed learning this topic’. In addition, eleven students strongly agreed, two agreed while one slightly agreed that they ‘would like other teachers to use this teaching method’. Furthermore, three students strongly agreed, five agreed while five slightly agreed that they ‘participated willingly during the lesson’. However, although students showed signs of enthusiasm towards learning, not all of the students completed the assigned work at home. Even when they missed a lesson, not everyone was responsible enough to inquire about the concepts discussed in class while they were away. Moreover, when asked to complete some follow up questions after watching a video at home, students used to copy the answers word for word from the video’s subtitles and when in class they were asked to explain further in their own words, they used to hesitate a lot and frequent prompting was required to enable them to do so. Some students showed that they have a very low self-efficacy and only one student showed signs of having a future-time perspective. Their ability to inquire was a bit low and in fact at times they had to be instigated in order to be able to do so.

When during the focus group, the students were asked whether they agree that they should be given homework, most of them agreed “because I tend to feel lazy when it comes to studying or revising after the lesson. So homework helps me revise" (Student L, Focus group) and "it reflects how I'm doing in the topic" (Student J, Focus group). However, some disagreed saying that "it's obligatory so I do it as quickly as possible" (Student M, Focus group). When in turn students were asked whether homework should be done on a voluntary basis they immediately said:

> Student L: No, not like that either.
> Student N: No, that's too much liberty.
> Student M: And it would be confusing.
> Student L: And if I don't feel like doing it, I won't do it.
> Student D: Yes, you would say 'I won't get a warning' so you don't do it.
> Student L: Yes, too much liberty.
> Student M: Yes, you wouldn't say, 'yes, let me do it so that I'll understand more'.
> Student E: You will become lazy then.
> Student M: Yes.

This conversation clearly shows how much students are still teacher dependent. Although some might not like getting homework, deep down they still want it since they know that if it is not given and enforced they would not revise and study on their own. They still need someone to give them that push in the right direction and tell them exactly what they need to do, because after all, they do wish to succeed.

From these observations, one can conclude that the participating students are still in stage two of Grow's model of self-directive learners. Although they are motivated to learn, they do not have that internal drive, thirst and willingness to learn that will push them to search for knowledge on their own. They still think that I am responsible for their learning and hence it depends on the activities I prepare and the content I expose them to that determines whether they succeed or not.

## 4.6 Did the Flipped Learning Technique help the students learn the concepts in the topic 'Nature of Matter, Atomic Structure and Chemical Bonding'?

Once the lessons regarding the topic 'Nature of Matter, Atomic Structure and Chemical Bonding' came to an end, the students were given a summative test (Appendix 11). Out of the 15 participating students, 14 took the test whilst one student was absent on the designated day. The test was designed in a way such that each given question tested whether the students achieved/partially achieved/did not achieve a particular intended outcome. The objectives behind every test question can be found in Appendix 12. A bar chart showing how many students achieved/partially achieved/did not achieve each of the objectives was hence constructed, as seen in Figure 8. In addition, the marks obtained by the students during the end-of-topic test were compiled in Table 3.

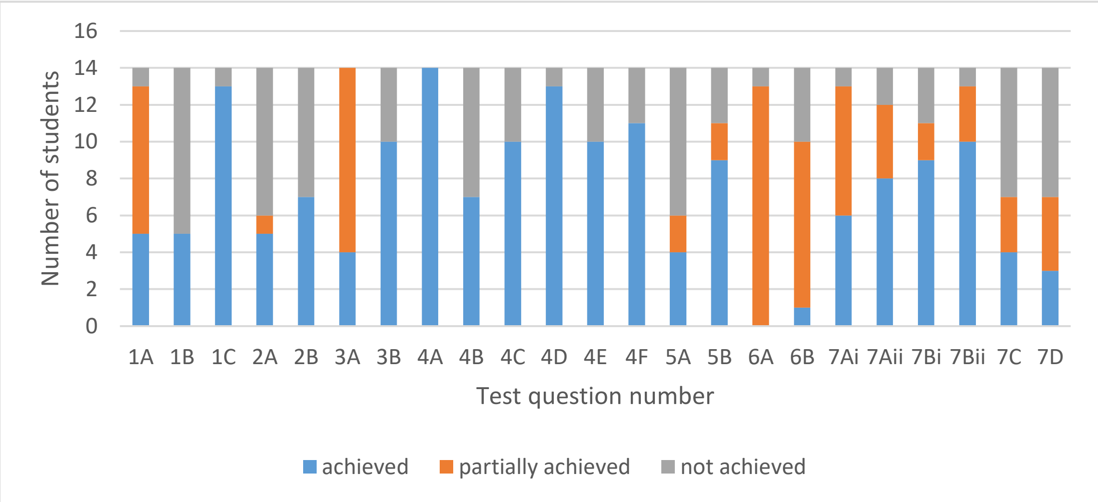


*Figure 8: A bar chart showing the number of students who achieved/partially achieved/not achieved the outcome indicated per test question*

*Table 3: The marks obtained by the students in their end-of-topic test*

| Student | End-of-topic test mark (%) |
|---|---|
| A | 76 |
| B | 86 |
| C | 78 |
| D | 30 |
| E | 24 |
| F | 42 |
| G | 78 |
| H | 52 |
| I | 30 |
| J | 78 |
| K | Absent |
| L | 82 |
| M | 50 |
| N | 50 |
| O | 86 |

As can be seen, most of the students did quite well in the end-of-topic test, with seven out of the fourteen participating students attaining a mark between 76% and 86%, three students scoring between 50% and 52% whilst only four students did not pass the test obtaining a mark between 24% and 42%. By taking each outcome individually, most of the objectives were reached by the majority of the students. Objective 4A was reached by all the students showing that all of them knew how to determine the number of electrons a particular atom has. Most of the students partially achieved objective 6A, revealing that they were still unsure how to write the formulae of compounds. Most probably this was due to the fact that the summative test was given a few days after the students had learned how to write formulae and hence they did not have enough time to assimilate what they had learned, study and practice. Objective 1B which was based on recall, that is, where students had to remember and write the name of the compound formed during the reaction between hydrogen chloride and ammonia gas, was the one that was not successfully reached by the majority of students. The results indicate that the students scored better in questions where they had to reason out things than when they had to simply recall factual information.

The students' half-yearly exam marks were also analysed. This examination included three topics, only one of which, 'Nature of Matter, Atomic Structure and Chemical Bonding' had been taught using the flipped learning, while the other two subjects were taught using traditional methods. The analysis sought to identify whether there was a significant difference between the marks obtained for the topics taught using different approaches. Table 4 illustrates the percentage of marks the students obtained in their half-yearly exam in each case.

*Table 4: The percentage marks students obtained in their half-yearly exams, firstly in questions regarding the topic tackled using the flipped learning technique and hence in questions whose topic was not taught in this way*

| **Student** | **Mark obtained when flipped learning was used (%)** | **Mark obtained when flipped learning was not used (%)** |
|---|---|---|
| A | 81 | 90 |
| B | 83 | 90 |
| C | 94 | 73 |
| D | 47 | 46 |
| E | 36 | 52 |
| F | 82 | 75 |
| G | 81 | 77 |
| H | 85 | 73 |
| I | 41 | 15 |
| J | 80 | 73 |
| K | Absent | Absent |
| L | 93 | 94 |
| M | 74 | 75 |
| N | 76 | 38 |
| O | 95 | 88 |

When the Pearson correlation coefficient was determined, there was a positive correlation (0.78) between the two sets of results. However, one cannot simply state that the flipped learning technique did not leave an impact on the students. This is because although at face value it seems that there is no significant difference between the grades obtained when the flipped learning technique was used and when it was not used, one has to keep in mind that firstly, the flipped learning technique could have helped the students improve skills which were not measurable through exam questions. Such skills include those regarding team work, communication, inquiry, metacognition and responsibility. The acquisition of these skills (amongst others) is very crucial. This is because we are living in an era that is very fast-paced, where the rate at which innovations are becoming outdated has accelerated and where technological breakthroughs are occurring on a day-to-day basis. For example, a few decades ago, when manufacturing industries were on the rise, employers sought workers who could perform routine and manual tasks. Today, with the newly developed technological advancements, such jobs are on the decline and hence employers are now engaging workers who are able to accomplish non-routine tasks, who are able to think in atypical ways and who are able to apply what they know in order to solve problems (Autor, Levy & Murnane, 2003). Therefore, since "skills are quickly becoming a requirement that drives *tangible* and *measurable* increases in personal productivity and directly translates to sustainable competitive advantage in a global marketplace" (Bancino & Zevalkink, 2007, p.22) equipping students with skills apart from knowledge is imperative.

The positive correlation between the two sets of results obtained can also be due to the fact that although student achievement is highly affected by the pedagogies teachers make use of, this is not the only factor that has an impact on students' grades. On the contrary, "performance of students is affected by psychological, economic, social, personal and environmental factors" (Singh, Malik & Singh, 2016, p. 176). For example, on a students' personal level, if they have a high level of self-efficacy and motivation (Schunk, 1995), possess good study methods (Nonis & Hudson, 2010) and bear good communication skills (Mushtaq & Khan, 2012) they are more likely to obtain higher grades. Considering another factor, that is, the students' home environment, it is found that students who come from a family of a high socio-economic status tend to do better in school than those who do not. This is because this usually implies that the students' basic needs are well satisfied and hence according to Maslow's hierarchy of needs when they go to school they are much more susceptible to seek self-actualization (Burney & Beilke, 2008). In addition, parents who have a high level of education tend to provide the adequate home environment that stimulates and encourages learning (Marzano, 2003). Such parents also tend to get more involved within their children's educational journey by engaging with them in discussions regarding school related work and activities, by participating in activities organised by the school and by providing them with the necessary help whenever they encounter a difficulty whilst completing their work at home (Fantuzzo & Tighe, 2000). However, since information regarding students' background was not collected, the students' achievement level in relation to their home environment could not be analysed.

Therefore, to conclude it is very difficult to state whether the flipped learning technique alone did or did not have a positive influence on the students' attainment grades due to the various factors that affect students' achievement levels. However, one can certainly affirm that the flipped learning technique directed the students towards the acquisition of skills that will help them become self-directed life-long learners.

## 4.7 Conclusion

Whilst evaluating in what way students were affected by the fact that they had to get themselves prepared before class, it was found that this approach helped them reduce their cognitive overload. This was due to a number of reasons. Firstly, the way the worksheets and the given videos were designed helped the students focus on the important material and disregard any irrelevant material. In addition, the fact that they were allowed to go through the provided material at their own pace continued to decrease the burden on their cognitive load. The students' motivation in engaging with this new approach to learning was found to be affected by two factors, that is, value and expectancy. On the one hand, students were found to be intrinsically motivated, mostly due to the novel tasks they were presented with. In addition, one student was found to be also stimulated due to having an extended 'Future Time Perspective' (Simons et al., 2004, p.122). On the other hand, in some cases, students' motivation seemed to decrease due to their low self-efficacy. The fact that the novelty effect of this new approach wore off over time, may also have had an impact.

Whilst employing the flipped learning technique, my job as a teacher was altered significantly from that within a traditional classroom. Instead of simply shifting factual information to the students, I took on a more professional role, using my expertise in order to design the most adequate learning activities that befitted my students' needs. In addition, I offered my students support and guidance throughout their learning journey, helping them overcome the difficulties and misconceptions they met along the way. Furthermore, I employed assessment techniques that offered the students the necessary feedback that aided them to improve their work.

To conclude, using Grow's (1991) model of self-directed learning, it was found that the students participating in this study are still in the second stage where, although they can be motivated to learn, they are still very teacher-dependent and have not taken ownership over their learning. They only study and carry out the tasks provided by the teacher and do not seek ways on how they can do better on their own. Finally, students were found to have succeeded in reaching a good number of the objectives set by the teacher as indicated in the MATSEC syllabus. When the Pearson correlation coefficient was calculated between the marks the students obtained in their half-yearly exams on questions regarding the topic 'The Nature of Matter, Atomic Structure and Chemical Bonding' (which was taught using the flipped learning technique) and the marks obtained in other topics, it was found that there is a positive correlation between the two sets of results. Although one cannot definitely determine whether the flipped learning technique did have a positive impact on the students' grades, one can surely assert that this approach has aided the students in the acquisition of skills and directed towards the path of self-directed learning. In addition, it clearly shows that students did not perform less well when the flipped learning technique was used.

# Chapter 5

# CONCLUSIONS AND RECOMMENDATIONS

# Chapter 5: Conclusions and Recommendations

## 5.1 Introduction

This research sought to explore the use of the flipped learning technique with a group of fifteen Year 9 students attending a co-ed state school in Malta. In this chapter, the main findings will be summarized and their implications discussed. In addition, the strengths and limitations of the study will be reviewed along with recommendations for future research.

## 5.2 Summary of the Main Findings

The findings made will be described in the sections below in relation to the research questions.

### 5.2.1 How was the flipped learning technique used in order to teach the topic 'Nature of Matter, Atomic Structure and Chemical Bonding'?

Firstly, the objectives of the topic that were to be tackled had to be identified. Then, these had to be sorted into two categories, that is, those which the students could reach whilst they were on their own at home, and those which could be reached in class with the teacher's guidance. The tasks which students had to carry out at home in order to gain the factual knowledge were then prepared. In this case, a student homework pack was created such that it contained the objectives students were meant to reach during each activity as well as links to You-tube videos which the students could watch and gather knowledge from. The videos were accompanied with follow up questions which the students could work out in order to determine whether they had truly understood the video's content or not.

When students came to class, they were prompted to explain what they learnt at home and they were also encouraged to ask questions regarding any difficulties they encountered. In this way, the students' level of understanding could be checked and, if any misconceptions emerged, they could be dealt with immediately. Class time was then filled with tasks I had previously prepared and compiled in a student's classwork pack. Whilst completing these tasks, group work and peer tutoring were encouraged. During these activities, I went round the students, prompting them in order to guide them towards the desired path, answering difficulty questions, praising them for their achievements and providing them with the appropriate level of individual support. Different kinds of formative assessment tasks were also set up. These helped the students gain the necessary feedback regarding whether they had reached the desired objectives or not.

### 5.2.2 What was the impact of this technique on students' performance with respect to the learning outcomes as specified in the chemistry syllabus?

From the end-of-topic test which was assigned to the students once all the activities were carried out, it was determined that most of the students did grasp the targeted concepts well, even though a new approach to learning was used. Overall, when the results were investigated it was determined that students did better in questions which required reasoning than in those requiring the recall of factual information. Although this was not deeply investigated, this could have been due to the fact that during the learning activities factual information was not being emphasized as much as usual and more focus was given on thinking skills.

Finally, the marks students obtained during their half-yearly exam were evaluated. It was found that there was a positive correlation (0.78) between the percentage of marks obtained from those topics taught with the flipped learning technique and the percentage of marks attained from those topics taught using other methods. Although due to this positive correlation, it may first appear that the flipped learning technique did not result in improvement in the students' attainment level, such conclusions cannot be made. This is because, first of all students could have gained skills which were not assessed by the half-yearly exam, given that this tested mainly recall and understanding. Such skills include those regarding reasoning, team work, communication and inquiry. In addition, the students' achievement levels did not depend only on the pedagogies used but also on social, environmental and personal factors which were not taken into consideration during the analyses of results.

### 5.2.3 What were the students' views on the flipped learning approach with regards to their engagement, motivation and learning?

Overall the participating students liked the flipped learning approach for several reasons. These include the fact that they felt more mentally prepared for the upcoming session, their working memory was less overloaded and the provided You-Tube videos were fun to watch and allowed them to learn at their own pace.

Different students portrayed different levels of motivation when the flipped learning technique was used. This was influenced by two factors, that is, the value they attributed to the given tasks themselves as well as their level of self-efficacy. This approach was at first valued by most of the students because it incorporated a technological aspect and hence, they regarded this technique as being novel. Unfortunately, with time, this approach did not remain so novel and this resulted in a decrease in the students' motivation. One student was found to have an extended 'Future Time Perspective' (Simons, Vansteenkiste, Lens & Lacante, 2004) due to the fact that she found this approach motivating due to its utility value for her future studies in a post-secondary school.

Some students were found to have a high self-efficacy and they persisted and continued doing the tasks at home even though they might have found them a bit challenging. In addition, even when they missed a lesson, they used to ask their friends what the next task was and hence, since they had the homework pack with them at home, they used to attempt the given task all the same. However, this cannot be said for every student. On the contrary, most of the students decided not to do the tasks whenever they found them challenging as a result of their low level of self-efficacy. Definite conclusions regarding their choice of not doing the tasks at home cannot be determined and so other reasons such as those regarding their high level of dependence on the teacher cannot be ruled out.

Whilst in class, teacher-set questions helped the students remember the concepts they had learned at home and enabled the identification of any difficulties and misconceptions such that these could be addressed accordingly. During the sessions, students were also found to lack inquiry skills and hence they had to be prompted and instigated such that they could ask inquisitive questions that would lead them to gain more knowledge. When given the opportunity to work in groups, most of the students seemed to be very eager to do so. However it was found that, whilst friendship groups made students feel comfortable to work with each other, these were problematic as they led to an increase in the level of socialising and hence more students ended getting off task. In addition, in cases where students of low achievement levels worked together, collaboration proved to be more difficult to occur. Whilst carrying out tasks, both in groups or individually, student support and guidance was always provided. These varied from simply reminding the students of concepts which they would have forgotten, to helping students organize their thoughts. The assessment tasks given also provided the students with instant feedback on how they could improve their work.

Finally, from the data collected it was found that the students are still very teacher-dependent and are still in stage two of Grow's (1991) model of self-directive learners. This because although they showed signs of motivation, they still do not possess that thirst that drives them to search and gain knowledge. They still think that their teacher is responsible for their learning and the idea of taking ownership over their own learning is too shocking for them. However, one must keep in mind that this was the students' very first experience of the flipped learning technique. I believe that if they continue to be exposed to this approach and are provided with the necessary support, they will eventually get accustomed to it and become more autonomous learners.

## 5.3 Implications of the Study and Recommendations for Practice

Sometimes when knowledge is too factual and abstract to be elicited from the students themselves, direct instruction may be necessary. However, the classroom is not necessarily the place where this should take place. This is because, as has been found in this study, if students are equipped with suitable resources (such as videos), of the appropriate difficulty level and provided with the correct amount of support they are able to learn most of the factual material on their own.

Shifting the learning of factual information to home first of all implies shifting the responsibility of learning from the teacher onto the students. This is one of the most difficult steps that one has to make when utilizing the flipped learning technique. But it is “when learning is in the hands of the students and not in the hands of the teacher, [that] real learning occurs” (Bergmann & Sams, 2012, p. 111). Unfortunately, the students participating in this study are still very teacher dependent and they are almost afraid of being held responsible for their own learning because they do not know how to handle it. I believe that this is due to long years of traditional teaching they have been exposed to where they have been taught that it is their duty to sit silently, listen to and do whatever the teachers tell them to. I believe that it is about time that things change. “Teachers need to see students not as helpless kids who need to be spoon-fed their education, but rather as unique individuals who require a unique education” (Bergmann & Sams, 2012, p.112). But how can such a drastic change take place?

I think that those teachers who wish to make this major leap, should firstly communicate things with their students. This is because students should know what being responsible for their learning means and what it entails. This will help them realize the value of such an action and help them be more committed towards their work. Together with their teacher, the students can reflect on themselves as learners, identify their strengths and weaknesses, establish strategies that will be the most effective to reach their goals and hence determine ways of how they monitor their progress.

> Introducing students to the skills they need in order to take independent action and learn how to learn… will help prepare students to adapt in a changing world. Many learners come back to school without a full understanding of what it takes to become a successful learner. They need to understand that what they need to learn and what they do to learn are different (Ford, Knight & McDonald-Littleton, 2001, p.61).

On a day-to-day basis, teachers can continue encouraging their students to take ownership of their own learning by employing small strategies that will surely leave a big impact. These include giving students a choice on how to present their findings when carrying out a project, asking open-ended questions which invite students to think critically and organising learning activities which require students to plan, discuss, share ideas and collaborate together. It would be ideal if students are exposed to these type of activities from a very early age, that is, during their primary school years. In this way, being self-directed with regards to their studies becomes second nature to them.

I believe that the flipped learning technique will be especially useful when the 'Learning Outcome Frameworks' (LOFs) start being implemented in our senior schools in September 2020. This is because the aim of the LOFs "is to free schools and learners from centrally-imposed knowledge-centric syllabi, and give them the freedom to develop programmes that fulfil the framework of knowledge, attitudes and skill-based outcomes that are considered national education entitlement of all learners in Malta" (Attard Tonna & Bugeja, 2016, p. 170). With less emphasis being placed on knowledge and more focus being placed on skills, the flipped learning technique would hence be ideal since it frees up class time allowing teachers to organize activities which promote the acquisition of higher-order thinking skills.

The flipped learning technique would be even more ideal due to the fact that "the reform will be accompanied by a change in the assessment regime… [where]

Assessment of Learning, for Learning and as Learning will be promoted with all educators for the benefit of learners" (Attard Tonna & Bugeja, 2016, p.170). With class time being freed up, teachers would have more time to set up formative assessment tasks that go beyond gauging the students' ability to recall factual information. On the contrary, they would have time to organize assessment activities through which they can check how much students are able to apply what they have learned in a practical every-day situation, analyse and evaluate a set of results obtained from an authentic survey and formulate solutions to real world problems. Through these assessment activities, good learning behaviours are reinforced and students are directed away from the tendency to study the night before the exam simply to gain good grades on their summative tests (Kulasegaram & Rangachari, 2018).

Being of such great value, professional development (PD) sessions can be organised amongst teachers (not just chemistry teachers), such that they are made aware of how the flipped learning technique works and what its benefits are. Hence, workshops can be organized such that teachers can discuss how different concepts can be taught through this method. This is because as Attard Tonna & Bugeja (2016) pointed out "a real impact in the classrooms does not simply come about by the introduction of new policies, but by educators owning the process of change" (p. 171).

## 5.4 Strengths and Limitations of the Study

During this study, the flipped learning technique has been used to deal with just one topic, that is, 'Nature of Matter, Atomic Structure and Chemical Bonding'. This topic is quite factual in nature and contains many abstract concepts. Having tested this technique on solely one topic makes it difficult to say whether the same technique could be used when dealing with other topics which contain more experimental work or mathematical calculations. Moreover, being a case study, this approach was only tested amongst a small group of students (fifteen in total) who attended one particular school, that is, a state school. This means that the results obtained during this study cannot be generalized. Bassey (1999) states that when qualitative research such as a case study is carried out only “fuzzy generalization” can be made. These claim “that *it is possible, or likely, or unlikely that* what was found in the singularity will be found in similar situations elsewhere” (p.12).

However, having carried out a case study did have its benefits. This is because this type of research has given me the opportunity to delve into one particular situation and depict thick descriptions of how the flipped learning technique impacted the students involved. The research methods employed were also described in great detail such that the same case study can be replicated with other groups of students. In addition, the fact that many research tools were used in order to collect data implies that the findings made are more valid and reliable.

Due to time limitations, during this research it was decided that ready-made You-tube videos would be given to the students such that they would be able to watch them at home and gain the necessary information. These type of videos were very hard to come by and in fact, at times no videos could be found on specific concepts such as how to construct a model of a molecule in a step by step procedure. Some of the videos found were also too long and depicted teachers who recorded themselves giving out a lesson. These were immediately disregarded since it had been decided that the tasks given out should be motivating for the students and would only take a short amount of time to complete.

Student homework packs were created for the students to use whilst at home. On the one hand, these were beneficial since before the start of the research students were concerned about whether they will be given the usual pack of notes. Having these worksheets helped them feel reassured that they would still have the necessary notes from which they could study for their exam. However, since these tasks were not compiled on a website, there was no way of tracking the students and checking whether they had truly watched the given videos or not.

## 5.5 Possibilities for Future Research

Being such a new learning approach, further research on the application of the flipped learning technique is highly recommended. The following are some research questions which one might take into consideration and build upon whilst carrying out their research.

- How can the flipped learning technique be used to deal with other topics?
- What are the teachers' views on this approach?
- Is there any significant difference between the views obtained from both teachers and students in state schools and those coming from independent and church schools?
- What kind of support and resources do teachers need such that they are able to apply this approach within their classrooms?
- Do all students benefit from the flipped classroom technique? What kind of support is needed such that this technique works?
- What skills are students gaining due to the use of this technique?
- Are students being more responsible for their own learning after this technique has been used for a number of years?
- What differences are teachers experiencing after applying this technique for a number of years?

## 5.6 Conclusion

This study revealed that although some topics may contain a number of factual and abstract concepts which are very difficult to elicit from the students, the acquisition of information can be shifted and carried out at home. In this way, class time is freed for more beneficial activities. Although such an approach requires a drastic change in mentality, now that a new educational reform is approaching, it is the ideal time for one to reflect on his/her pedagogies and identify how, as a teacher, s/he can be the best guide and facilitator rather than a dictator of knowledge. This will help students to become responsible for their own learning such that “when the student is ready the teacher appears. When the student is truly ready the teacher disappears” (Lao Tzu – Chinese Philosopher).

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# APPENDICES

# Appendix 1

# HISTORY OF THE FLIPPED LEARNING TECHNIQUE

## History of the Flipped Learning Technique

The idea of shifting the acquisition of basic concepts out of class in order to be replaced with more active in-class activities that ensure deeper understanding, is not a recent phenomenon in the academic world as one might think. In fact, since the 1850s, cadets attending the United States Military Academy at West Point have been taught subjects like maths, science and engineering using the Thayer method of instruction (Shell, 2002). At the academy, cadets were placed in small classes where they dealt with content for three hours at a great depth. They were required to go to class prepared by learning on their own the material that was assigned to them. In this way, once they were in class they would prepare their work on the chalkboards and recite the concepts learned to their instructor. During the presentation, the instructor used to ask them questions in order to test their knowledge. After demonstrating the acquisition of sound knowledge, the cadets would collaborate together in order to work out new problems based on the material covered, enabling them to achieve more profound understanding. This left no time for lecturing. Instead, the instructor's job was to grade each and every cadet based on their written and oral work on a daily basis. This allowed the restructuring of groups upon merit and achievement such that each cadet would then be given "a task of study proportional to his capacity" (Shell, 2002, p.29).

A similar strategy was adopted by two organic chemistry teachers, Morrison and Boyd, who thought that lecturing was only suitable "a very long time ago, when books were rare and very expensive, and the only way to transmit information was for the teacher, who knew, to tell the students, who did not yet know" (Morrison, 1986, p.52). In 1959, they published their first organic chemistry book which consisted of detailed, yet simple explanations which students could simply read and understand on their own as if they were hearing their teachers lecturing out loud in their very own classroom. With this book available in their students' own hands, they felt ridiculous reciting what was already present in their publication. Faced with the problem of what to do during class time, Morrison happened to attend a presentation by Frank Lambert, a graduate student who taught at Occidental College in California, where he learned about the Gutenberg method. This method required students to study parts of the text-book before attending class. In this way, students would have had the opportunity to think about the concepts studied so that when they are actually in class they would be able to engage in discussions and ask questions (Morrison, 1986).

Over the years, several scholars shared their concern about the diminished effectiveness of the lecture method and the need to move away from this method of teaching. These include George Atkinson who in 1970 in his paper ‘Stop Talking and Let the Students Learn to Learn’ states that during lessons teachers should not simply paraphrase the content found in books which he called “Bound Optimally Ordered Knowledge (BOOK)” (p.561). Instead they should teach their students how to study on their own in order to be prepared “today for jobs which will exist tomorrow” (p.562). In 1993, Alison King also declared that students should be active participants in their own learning and hence teachers should shift from being the “sage on the stage” to being the “guide on the side” (p.30). She also proposed several ways in which this can be achieved. Such activities include ‘think-pair-share’, drawing concept maps and flowcharts as well as group work activities (King, 1993).

In the last century, huge leaps in technological advancements have also been made and these have increased the availability of the required information as well as facilitated the spread of knowledge in different formats. Such inventions include, the television (1920s), the computer (1940s), the internet (1960s), the world-wide web (1990s), Google (1998) and Youtube (2005) (Bishop & Verleger, 2013). Chemistry teachers have long attempted to make use of information technology in their classrooms in order to improve their teaching methods as well as to reach out to more students and help them become independent learners. Back in 1970, chemistry lecturers at Ohio University, recorded their lectures on audio and video tapes and placed them in the University library so that students who missed a lecture or simply wanted to rehear it could be able to do so at any time (Day & Houk, 1970). Baker (2016) recounts how before 1995 there were no computers or projectors in his classrooms. He used to teach computer screen design through printed material until finally he was able to wheel in a computer and a couple of monitors from his office every time he had a lecture for the students to use. Later on that year, every dormitory at Cedarville College (his workplace) was supplied with a computer with the college's own network and projectors started being installed in many classrooms. With this newly acquired technology, Baker started uploading the presentations he displayed in class on the school's network.

With his teaching methods being steered to another direction, he soon realized that he was now faced with another problem: "I just gave away all of the content for the class. What am I going to do in class the rest of the term?" (Baker, 2016, p. 16). Inspiring himself through literature, Baker reorganized his class time by applying the following steps:

a) Clarify – First, any queries or difficulties encountered by the students whilst completing the assigned tasks or readings were discussed.
b) Expand – Then, students were encouraged to use their own experiences or any other material they would have read in order to broaden their knowledge and make it more meaningful.
c) Apply – Most of the class time was then used to complete tasks which involved the application of the learnt material, thus demonstrating whether a certain concept was mastered or not.
d) Practice – Finally, students were given tasks which not only involved the utilization of the learnt material but also the use of creative thinking through the collaboration with other students.

This method of teaching, where technology was used to deliver the necessary information and where class time was freed for more student interaction and student active participation under the guidance of the teacher, gave rise to the term 'Flipped Classroom'. However, it was not until the year 2000, that he gave a presentation about the Flipped Classroom Model during the 11$^{th}$ International Conference on College Teaching and Learning in Florida. From then on his ideas of what a flipped classroom should look like continued to expand and develop. In that same year, Lage, Platt and Treglia (2000) who worked independently from Baker, also wrote a paper in which they described the use of the inverted classroom method as a means to suit the needs of every single student given the fact that each person is unique and therefore learns in a different way from others. It is important to note that the students within the flipped classrooms mentioned so far are mostly post-secondary students.

A crucial step forward was then made by Salman Khan, a graduate from the Massachusetts Institute of Technology, who in 2006 founded the Khan Academy, launching a collection of over 3,200 videos and 350 exercises which one can use to practice on, with the aim of providing "a free world-class education to anyone anywhere" (Bishop & Verleger, 2013, p.3). His videos, which are all about seven to fourteen minutes long, include subjects such as mathematics, science and economics. They consist of a voice-over carried out by Khan himself while he scribbles formulas and diagrams which help him explain a particular concept or problem. Besides watching videos, one can also take up practice exercises, quizzes and tests. After being asked a series of questions, one is awarded a badge just like in videogames. Furthermore, Khan Academy also provides teachers with a dashboard to monitor their students while they make use of the resources provided so that they would be able to help them out the minute they stumble upon a problem. As a result, high-flying students are able to continue moving forward whilst students who struggle are able to get the attention and help that they need. Khan's brilliant website has caught the eye of many, including Bill Gates, who has invested $1.5 million in this site after realizing how such a webpage can cater for the students' individual needs (Thompson, 2011). Nowadays many others have followed in Khan's footsteps and have created their own online tutorials which can be used by students in order to deepen their knowledge about different subjects.

The term 'flipped classroom' however, gained popularity in 2012 when Jonathan Bergmann and Aaron Sams, two chemistry teachers from Woodland Park High School in Colorado wrote a book called 'Flip your classroom: Reach every student in every class every day'. These two teachers who have the students' best interest at heart, always sought ways of how they could give their students the best educational experience. They wanted the students to not just get good grades, but also have a deep understanding of what chemistry is all about. Furthermore, the one-to-one interaction with the students in their class was of crucial importance because they believed that by getting to know their students they would be able to personalize their teaching and adapt to the students' different needs. They therefore decided to flip their classroom and write their journey in a book which depicts not only how they did it but also the reason behind every decision they made along the way. They included not only their successes, but also their mistakes, not only their best practices, but also their precarious first steps which enabled other teachers to relate to their experiences and hence get encouraged to try out this new teaching technique (Bergmann & Sams, 2012).

As a result, Bergmann and Sam's book was a huge success and in fact Bergmann himself has been invited to speak and train school teachers worldwide. Michigan's Clintondale High School in the United States, was one of the very first schools that embraced this new pedagogy and flipped every classroom, recording lectures and using class time more effectively (Raths, 2014). Moreover, MEF University in Turkey was the first University that has fully endorsed the flipped learning technique (McKeown, 2016). Due to the high response rate, in June 2016 Bergmann launched the Flipped Learning Global Initiative (FLGI); an online "worldwide coalition formed to support the successful adoption and implementation of flipped learning across the globe" (Flipped Learning Worldwide, 2018).

To this date, many milestones have been achieved, including the enrolment of 2,500 teachers for the certification program, the completion programme of 40 flipped learning trainers as well as the various flipped conferences and workshops that were organized.

# Appendix 2

# PERMISSION TO CARRY OUT STUDY IN STATE SCHOOLS

DIPARTIMENT GĦALL-KURRIKULU, RIĊERKA, INNOVAZZJONI U TAGĦLIM TUL IL-ĦAJJA
FLORIANA FRN 1810

DEPARTMENT FOR CURRICULUM, RESEARCH, INNOVATION AND LIFELONG LEARNING
FLORIANA FRN 1810

**Directorate for Research, Lifelong Learning and Employability**

**Tel: 25982265** **researchandinnovation@ilearn.edu.mt**

## PERMISSION TO CONDUCT RESEARCH STUDY

**Date:** 14th November 2017

**Ref:** RI2017/015

**To:** **Head of School**
**From:** **Assistant Director (Research and Innovation)**

**Title of Research Study:** The Flipped Chemistry Classroom A Case Study of Year 9 Students Views and Performance

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The Directorate for Research, Lifelong Learning and Employability would like to inform that approval is granted to **Graziella Schembri** to conduct the research in State Schools according to the official rules and regulations, subject to approval from the Ethics Committee of the respective Higher Educational Institution.

The researcher is committed to comply with the Data Protection Act and will ensure that these requirements are followed in the conduct of this research.

Thank you for your attention and cooperation.

Ruth Muscat

Research Support Teacher

f/Grazio Grixti
Assistant Director (Research and Innovation)
Directorate for Research, Lifelong Learning and Employability
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MINISTRY FOR EDUCATION AND EMPLOYMENT

# Appendix 3

# INFORMATION SHEETS AND CONSENT FORMS GIVEN TO SCHOOL PRINCIPAL, HEAD OF SCHOOL, STUDENTS’ PARENTS / GUARDIANS AND STUDENTS

## Information Sheet for School Principal and Head of School

Dear ___________________,

I am currently reading for a Masters in Science Education at the University of Malta. As part of this course, I will be conducting a research study under the guidance of my supervisor Dr. Josette Farrugia.

For my dissertation, I have chosen to carry out a case study in order to investigate the use of the flipped classroom technique with a group of Year 9 Chemistry students. Their experience and views regarding this approach will be evaluated. I would like to study this new pedagogy in an attempt to make lessons more student-centred even when abstract concepts are being addressed. In this way, students will be more engaged during the lesson and more time is allocated for students in order to carry out hands-on activities.

I would therefore like to ask for your permission in order to conduct this study at your school. My research will consist of a number of lessons that will address a specific topic where the main pedagogy used will be the flipped classroom technique. This approach entails the allocation of short tasks which the students need to carry out at home, for example watching a You-tube video and answering three follow up questions. Then, during the lesson, students will discuss what they have learned from the task, any difficulties or misconceptions are dealt with and the rest of the time in class would be used for hands-on activities which will continue to enhance the students' learning experience. After each lesson, students will be asked to reflect on the tasks done at home and at school. In addition, at the end of the topic being tackled, students will be asked to sit for an end-of-topic test, making sure that all the required outcomes have been reached. They will also be asked to fill in a 10 minute questionnaire containing Likert scale items as well as participate in a focus group so that I will be able to get a deeper understanding of the students' views regarding the use of the flipped classroom technique. During the focus group, students will be voice recorded.

The flipped classroom approach will be used with all the students within my class since it caters for the different needs of all students and is beneficial to all. In addition, all the concepts prescribed by the curriculum will covered. The only difference will be in the way it is taught. However, it will be up to the students and their parents/guardians to decide if they are willing to participate in the data collection by filling in the questionnaire, writing down their thoughts in their reflective journal and voicing their opinions during the focus groups. Even if they decide to participate, they would be free to withdraw from the study whenever they like without incurring any penalties, such as deduction of marks with respect to the students' assessments, tests or exams. Moreover, the focus group will be carried out on the last day of their mid-yearly exams so that students would not miss any lessons or other school activities.

I would like to assure you that confidentiality will be respected at all times. This means that the name of the school will only be known to me and my supervisor and pseudonyms will be used in the writing of my dissertation. Moreover, all the data collected will be stored in my laptop and will be password protected so that it can be only accessed by me. It will then be destroyed two years after my graduation since it will not be used for further research. Furthermore, I would like to assure you that I will always abide by the ethical guidelines published by the Faculty Research Ethics Committee (FREC) and the University Research Ethics Committee (UREC).

Once I graduate it would be my pleasure to share the results of my research with you. In the meantime, should you require any further information, please do not hesitate to contact me. Thank you very much in advance for your help.

Yours faithfully,

Graziella Schembri
Mob: 99053926
Email: graziella.schembri. 09@um.edu.mt

Supervisor:
Dr. Josette Farrugia
Email: josette.farrugia@um.edu.mt

**Information Sheet given to Parents/Guardians**

Dear parents / guardians,

I am Ms. Graziella Schembri, your daughter's / son's chemistry teacher. I am currently reading for a Masters in Science Education at the University of Malta.

As part of my course, I am conducting a study about the teaching and learning of Chemistry. This study will be about students' views on teaching methods and activities used in chemistry lessons. I would therefore really appreciate it if you give your consent for your son/daughter's participation in this study. The supervisor is Dr. Josette Farrugia.

Participation would require that students write down their thoughts regarding their homework and the activities carried out in class. In addition, they would be required to participate in a group discussion and fill in a short 10 minute questionnaire related to the Chemistry lessons.

The group discussion will be around 30 minutes long and will take place at school on the last day of their half-yearly exams. In this way they will not miss any lessons or other school activities. In addition, the students' voice will be recorded during the group discussion. However, their identity will remain anonymous and no part of my dissertation write-up will be linked to them. All the data collected will only be accessed by me and used for my research only. It will then be destroyed two years after my graduation.

Participation in this study is voluntary. The given consent may be withdrawn any time and no consequences will follow. If you want your son/daughter to participate, please fill in and return the form attached to this letter.

Your son's/daughter's success is my priority and therefore researching how his/her learning experience can be improved lies at heart. Whilst I thank you for your help in advance, please do not hesitate to contact me in case of any difficulties.

Yours faithfully,

G. Schembri

Ms. Graziella Schembri
Mob: 99053926
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J. Farrugia

Supervisor:
Dr. Josette Farrugia
Email: josette.farrugia@um.edu.mt

**Consent Form given to Parents/Guardians**

This form is to be completed by those parents who **WANT** to give their son/daughter permission to participate in Ms. Graziella Schembri's study.

I, ___________________, give permission to my son/daughter _________________ to participate in Ms. Graziella Schembri's study. By signing this form:

- I confirm that I have read the information sheet explaining the purpose and method of study.
- I understand that participation is voluntary and that I can withdraw my consent whenever I like without any negative consequences on my son/daughter.
- I confirm that I am giving the permission to my son/daughter to:

| | Tick the boxes that apply to you |
|---|---|
| Write down his/her thoughts regarding their Chemistry lessons. | ☐ |
| Participate in the audio recorded group discussion. | ☐ |
| Fill in a 10 minute questionnaire about the chemistry activities and lessons. | ☐ |

Parent/Guardian's Signature: _______________ Date: ________________________

Signature: G. Schembri Signature: J. Farrugia

Ms. Graziella Schembri
Mob: 99053926
Email: graziella.schembri.09@um.edu.mt

Supervisor:
Dr. Josette Farrugia
Email: josette.farrugia@um.edu.mt

**Ittra ta' Informazzjoni mogħtija lill-Ġenituri/Kustodji**

Għeżież ġenituri/kustodji,

Jiena Graziella Schembri, l-għalliema tal-Kimika tat-tifel/tifla tagħkom. Bħalissa qiegħda nagħmel kors (Masters) fl-Edukazzjoni (M.Ed in Science Education) mal-Università ta' Malta.

Bħala parti minn dan il-kors ta' studju, qiegħda nagħmel riċerka fuq kif jiġi mgħallem s-suġġett tal-Kimika u fuq attivitajiet li jsiru waqt il-lezzjoni. Għaldaqstant, napprezza jekk tagħtu l-kunsens tagħkom lit-tifel/tifla tagħkom sabiex ikun/tkun tista' tieħu sehem f'din ir-riċerka. Is-supervajżer ta' din ir-riċerka hi Dr. Josette Farrugia.

Dan l-istudju jinvolvi li l-istudenti jiktbu x'jaħsbu fuq ix-xogħol tad-dar u l-attivitajiet li jsiru fil-klassi. Barra minn hekk, jiġu mitluba jieħdu sehem f'diskussjoni fi grupp u jwieġbu kwestjonarju qasir ta' madwar 10 minuti dwar il-lezzjonijiet tal-Kimika.

Id-diskussjoni bejn l-istudenti tal-klassi se tieħu madwar 30 minuta. Din se ssir l-iskola fl-aħħar ġurnata tal-eżamijiet ta' nofs is-sena, bl-għan li l-istudenti ma jitilfu la lezzjonijiet u lanqas attivitajiet skolastiċi oħra. Waqt id-diskussjoni, l-vuċijiet tal-istudenti se jkun qed jiġu rrekordjati, iżda l-identità tat-tfal se tibqa' mistura u fl-ebda punt ma ser jissemmew ismijiet, lanqas fil-kitba tat-teżi tiegħi. Jien biss se jkolli aċċess għall-informazzjoni miġbura u se nużaha biss għall-iskopijiet ta' din ir-riċerka. Din l-informazzjoni sejra tinqered fi żmien sentejn mill-gradwazzjoni tiegħi.

Il-parteċipazzjoni f'dan l-istudju huwa volontarju. Il-kunsens mogħti jista' jiġi irtirat meta tixtieq int mingħajr l-ebda penali. Jekk tixtieq li t-tifel/tifla tiegħek jipparteċipa/tipparteċipa f'dan l-istudju, jekk jogħġbok imla il-formula mehmuża ma' din l-ittra.

Il-ġid tat-tifel/tifla tiegħek jiġi l-ewwel u qabel kollox għalija. Għalhekk, din ir-riċerka qiegħda nagħmilha biex jitjieb il-mod kif jiġi/tiġi mgħallem/mgħallma għas-suċċess tiegħu/tagħha. Filwaqt li nirringrazzjakom bil-quddiem tal-għajnuna tagħkom, nitlobkom li tikkuntattjawni fis f'każ ta' diffikultà.

Dejjem tagħkom,

G. Schembri

J. Farrugia

Graziella Schembri
Mob: 9905 3926
Imejl: graziella.schembri.09@um.edu.mt

Supervajżer:
Dr. Josette Farrugia
Imejl: josette.farrugia@um.edu.mt

**Formola ta' kunsens mogħtija lill-Ġenituri/Kustodji**

Din il-formola ta' kunsens għandha tiġi mimlija **BISS** minn dawk il-ġenituri/kustodji li **JIXTIEQU** li t-tfal tagħhom jieħdu sehem fir-riċerka ta' Ms. Graziella Schembri.

Jien, ____________________, nagħti l-permess lit-tifel/tifla tiegħi ________________________ biex tipparteċipa fl-istudju li se tagħmel Ms. Graziella Schembri. Jien nikkonferma li:

- Qrajt l-ittra ta' informazzjoni, li spjegat l-għanijiet u l-metodi ta' din ir-riċerka.
- Qed nagħti l-permess b'mod volontarju, sabiex it-tifel/tifla tiegħi jieħu/tieħu sehem f'din ir-riċerka u nista' nirtira lura dan il-permess meta nixtieq jien mingħajr l-ebda konsegwenzi negattivi.
- Qed nagħti l-permess lit-tifel/tifla tiegħi sabiex:

| | **Agħmel sinjal fil-kaxxa/i li japplikaw għalik.** |
|---|---|
| Jikteb/tikteb l-opinjonijiet tiegħu/tagħha dwar il-lezzjonijiet tal-Kimika. | ☐ |
| Jieħu/tieħu sehem fid-diskussjoni fejn il-vuċijiet se jiġu irrekordjati. | ☐ |
| Jimla/timla l-kwestjonarju ta' għaxar minuti. | ☐ |

Firma tal-Ġenitur/Kustodju: _______________

Data: ________________________________

Firma: G. Schembri

Graziella Schembri

Mob: 9905 3926

Imejl: graziella.schembri.09@um.edu.mt

Firma: J. Farrugia

Supervajżer:

Dr. Josette Farrugia

Imejl: josette.farrugia@um.edu.mt

**<u>Information Sheet given to Students</u>**

Dear Student,

Apart from being your Chemistry teacher I am also a University student and at the moment I am doing a Masters in Science Education. As part of my studies I am carrying out research about the teaching and learning of Chemistry.

In order to carry out my research I would appreciate your help. In a few weeks' time, we will be starting Topic 2: 'The Nature of Matter, Atomic Structure and Chemical Bonding'. At the end of every lesson, I will ask you to spend 5 minutes writing down what you learned during the lesson, what you enjoyed doing, whether there were things that you did not enjoy and any other thoughts and opinions regarding the lesson. Then, at the end of the topic, you will be kindly asked to fill in a 10 minute questionnaire and to participate in a group discussion, where I will ask you some questions in order to obtain your views about the Chemistry lessons carried out.

The group discussion will take place at school on the last day of your half-yearly exams. In this way you will not miss any lessons or other school activities. In addition, your opinions and feedback will be voice-recorded during the group discussion. However, your name will not be written down in the study.

Your participation is voluntary. You are free to opt out at any time without any explanation or consequences. If you wish to participate in the discussion and fill in the questionnaire, please fill in the form attached with this letter and return to me. Your participation would be greatly appreciated. Thank you very much in advance.

Yours faithfully,

Ms. Graziella Schembri | Supervisor: Dr. Josette Farrugia

Email: graziella.schembri.09@um.edu.mt | Email: josette.farrugia@um.edu.mt

**Consent Form given to Students**

This form is to be completed by those students who **WISH** to participate in Ms. Graziella Schembri's study.

I, ______________________________, wish to participate in Ms. Graziella Schembri's study. By signing this form:

- I confirm that I have read the information sheet explaining the purpose of study.
- I understand that participation is voluntary and that I can withdraw my consent whenever I like without any negative consequences.
- I confirm that I want to:

| | Tick the boxes that apply to you |
|---|---|
| Write down my thoughts regarding the chemistry lessons. | ☐ |
| Participate in the audio recorded group discussion. | ☐ |
| Fill in the 10 minute questionnaire. | ☐ |

Student's Signature: ______________________

Date: ___________________________________

Signature: G. Schembri

Ms. Graziella Schembri

Email: graziella.schembri.09@um.edu.mt

Signature: J. Farrugia

Supervisor: Dr. Josette Farrugia

Email: josette.farrugia@um.edu.mt

**Ittra ta' Informazzjoni mogħtija lill-Istudenti**

Għażiż/a Student/a,

Minbarra li jiena għalliema tal-Kimika, jien ukoll studenta l-Università ta' Malta u bħalissa, qiegħda nagħmel kors (Masters) fl-Edukazzjoni (M.Ed. in Science Education). Bħala parti minn dan il-kors ta' studju, qiegħda nagħmel riċerka fuq kif s-suġġett tal-Kimika jiġi mgħallem.

Biex inkun nista' nagħmel din ir-riċerka, napprezza ħafna l-għajnuna tiegħek. Fi ftit ġimgħat oħra, sejrin nibdew it-tieni kapitlu msejjaħ: 'The Nature of Matter, Atomic Structure and Chemical Bonding'. Wara kull lezzjoni, se jkun hemm bżonn li tagħmel 5 minuti li fihom, tikteb ftit x'tgħallimt waqt il-lezzjoni, x'għoġbok, x'dejqek u ħsibijiet jew opinjonijiet oħra li jista' jkollok. Fl-aħħar tal-kapitlu, ser nitolbok biex twieġeb kwestjonarju ta' għaxar minuti, kif ukoll, biex tieħu sehem f'diskussjoni fi grupp. Waqtu, sejra nkun qiegħda nistaqsikom xi mistoqsijiet biex inkun nista' nieħu iktar l-opinjonijiet tagħkom tal-lezzjonijiet li se nkunu għamilna flimkien.

Id-diskussjoni se ssir l-iskola fl-aħħar ġurnata tal-eżamijiet ta' nofs is-sena, bl-għan li ma titlef la lezzjonijiet u lanqas attivitajiet skolastiċi oħra. Waqt din id-diskussjoni, leħnek se jkun qed jiġi rrekordjat, iżda l-identità tiegħek se tibqa' anonima.

L-għażla li tieħu sehem f'dan l-istudju hija f'idejk. Tista' tiddeċiedi li tastjeni milli tipparteċipa x'ħin jidhirlek u bla spjegazzjonijiet mingħajr ma teħel l-ebda' penali. Jekk tixtieq tieħu sehem fid-diskussjoni u timla' l-kwestjonarju jekk jogħġbok imla' l-formula mehmuża ma' din l-ittra. Napprezza tassew jekk tagħżel li tieħu sehem. Nirringrazzjak bil-quddiem tal-għajnuna tiegħek.

Dejjem tiegħek,

G. Schembri

J. Farrugia

Graziella Schembri
Imejl: graziella.schembri.09@um.edu.mt

Supervajżer: Dr. Josette Farrugia
Imejl: josette.farrugia@um.edu.mt

**Formola mogħtija lill-Istudenti**

Din il-formola għandha tiġi mimlija minn dawk l-Istudenti li **JIXTIEQU** jieħdu sehem fir-riċerka mmexxija minn Graziella Schembri.

Jien, _________________________, nixtieq nipparteċipa fl-istudju ta' Ms. Graziella Schembri. Jien nikkonferma li:

- Qrajt l-ittra ta' informazzjoni, li spjegat l-għanijiet u l-metodi ta' din ir-riċerka.
- Qed nipparteċipa f'din ir-riċerka b'mod volontarju u nista' nieqaf milli nkompli nieħu sehem f'dan l-istudju meta nixtieq jien mingħajr l-ebda konsegwenzi negattivi.
- Nixtieq:

| | **Agħmel sinjal fil-kaxxa/i li japplikaw għalik** |
|---|---|
| Nikteb l-opinjonijiet tiegħi dwar il-lezzjonijiet tal-Kimika. | ☐ |
| Nieħu sehem fid-diskussjoni fejn leħni se jiġi irrekordjat. | ☐ |
| Nimla l-kwestjonarju ta' għaxar minuti. | ☐ |

Firma tal-Istudent/a: ___________________

Data: _______________________________

Firma: G. Schembri

Graziella Schembri

Imejl: graziella.schembri.09@um.edu.mt

Firma: J.Farrugia

Supervajżer: Dr. Josette Farrugia

Imejl: josette.farrugia@um.edu.mt

# Appendix 4

# OBJECTIVES COVERED BY STUDENTS

# BOTH IN AND OUT OF CLASS.

## Objectives Covered by Students both In and Out of Class

| Lesson number | Objectives that were covered by the students at home (flipped) | Objectives that were covered by the students at school (not flipped) |
|---|---|---|
| 1. | • Explain how the theory of what stuff is made up of evolved.<br>• Explain simple observations using the particle theory. | • Define diffusion.<br>• State what factors affect the rate of diffusion.<br>• Explain Brownian's Motion. |
| 2. | • State what an atom is.<br>• Explain what an atom is made up of.<br>• Determine the number of sub-atomic particles in different atoms. | *(Formative assessment regarding atomic numbers, mass number and the number of sub-atomic particles.)* |
| 3. | • Explain the structure of the atom. | • Write the electronic configuration of various atoms.<br>*(Formative assessment regarding the drawing of various atoms.)* |
| 4. | | • Predict whether an atom represents a metal, non-metal or noble gas from the electronic configuration.<br>*(Continuation of formative assessment regarding the drawing of atoms.)* |
| 5. | • Define the term isotope.<br>• Work the amount of protons and neutrons in different isotopes. | • Calculate the Relative Atomic Mass (R.A.M.) of various elements. |
| 6. | • Explain what happens when a metal bonds with a non-metal. | • Draw dot-cross diagrams to represent the ionic bonding of various compounds.<br>• Determine the charges of the cations and anions.<br>• Write the electronic configuration of ions. |
| 7. | | *(Formative assessment regarding ionic bonding.)* |
| 8. | | • State the properties of ionic compounds.<br>*(Checkpoint regarding any misconceptions about ionic bonding.)* |

| | | |
|---|---|---|
| 9. | • Explain what happens when a non-metal bonds with a non-metal. | • Draw dot-cross diagrams of various molecules. |
| 10. | | • State the properties of covalent compounds.<br>*(Formative assessment regarding both ionic and covalent compounds.)* |
| 11. | • Explain what valencies are and why they are useful. | • State what polyatomic ions are.<br>• Write chemical formulae. |
| 12. | | *(End-of-topic test.)* |

# Appendix 5

# STUDENTS' HOMEWORK PACK

# NATURE OF MATTER, ATOMIC STRUCTURE AND CHEMICAL BONDING

Homework

## What is stuff made of?

**Objective:**

- To explain, how the theory of what stuff is made up of, evolved.

**1) Watch the You-tube Video: The 2,400-year search for the atom**

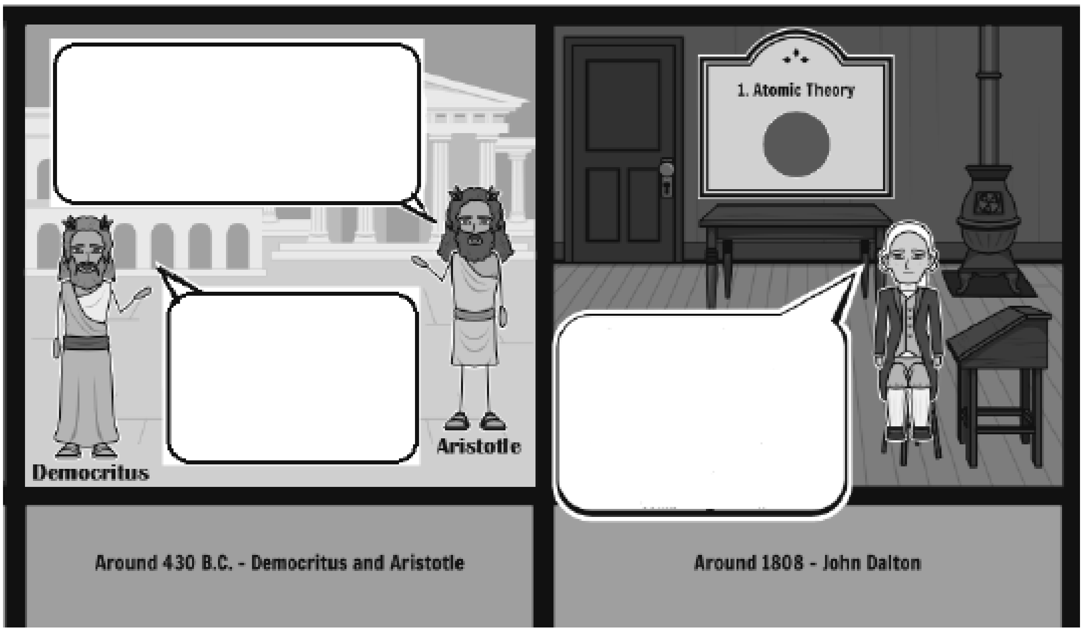
URL: https://www.youtube.com/watch?v=xazQRcSCRaY&ytbChannel=TED-Ed

(Watch only from 00:00 till 01:45)

**2) Answer the following question:**

According to Democritus, Aristotle and Dalton, what are different substances made up of?

(Write your answer in the bubbles below to complete this comic cartoon.)



# How can you prove that particles really exist?

**Objective:**

- To explain simple observations using the particle theory.

Scientists still believe that everything is made up of particles. Yet particles are too small to be seen. Even if you use the most powerful microscope, you can't really 'see' them. So why are we sure that they really exist?

**Carry out the following activities and then answer the following questions:**

1) A) Place a few drops of food colouring in a glass of water. What happens?

______________________________________________

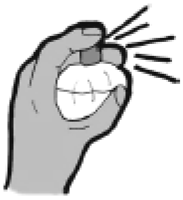
B) Why do you think this happens? (Try to explain in terms of particles).

______________________________________________

______________________________________________

2) A) Ask someone to stand far away from you in a closed room. Spray some perfume. What happens after some time?

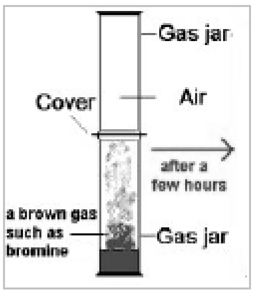
______________________________________________



B) Why do you think this happens? (Try to explain in terms of particles).

______________________________________________

______________________________________________




3) A) An open gas jar is placed upside down on a closed gas jar of red-brown bromine vapour as shown in the picture on the left. The glass cover between the two gas jars is then removed. What happens? ______________________________________________

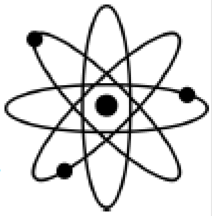
B) Why do you think this happens? (Try to explain in terms of particles).______________________________________________

## What are atoms made up of?

**Objectives:**

- To state what an atom is.
- To explain what an atom is made up of.
- To determine the number of subatomic particles in different atoms.

1) Watch the You-tube video: What is an atom? | Chemistry | the virtual school:
https://www.youtube.com/watch?v=qzGhi_KC7Ec&ytbChannel=FuseSchool%20-%20Global%20Education



- What is an atom?

_______________________________________________

2) Watch the You-tube video: Parts of an Atom | Chemistry | FuseSchool:
https://www.youtube.com/watch?v=cpBb2bgFO6I&ytbChannel=FuseSchool+-+Global+Education

- Atoms are made up of 3 subatomic particles called ____________________, ____________________ and ____________________.

- Atoms are very ______________ and contain a lot of ______________ space.

- Complete the following table:

| Sub-atomic particle | Symbol | Mass (a.m.u) * | Charge |
|---|---|---|---|
| Proton | p | | |
| Neutron | n | | |
| Electron | $e^-$ | | |

* All the sub-atomic particles in an atom are very light. Their mass is measured in **atomic mass unit (a.m.u)** rather than in grams.

- Atoms are always **NEUTRAL** because ______________________________________________

______________________________________________________________________

3) Watch the following You-Tube video: Atomic Number and Mass Number | Chemistry for All | Fuse School https://www.youtube.com/watch?annotation_id=annotation_1494712751&feature=iv&src_vid=_S7ov25y3_M&v=gUA8k4gOpbk&ytbChannel=Fuse School%20-%20Global%20Education

- Label the following diagram:

This **LARGE** number is called the ____________________ and it shows how many ______________ and ____________ 1 atom of Aluminium has.

This **SMALL** number is called the ____________________ or **proton number** and it shows how many ______________ 1 atom of Aluminium has.

27
Al
13

- Therefore, Aluminium has: ________ protons

  ________ electrons

  ________ neutrons

- Let's take another example. Look at the element sodium below and answer the following questions

23
Na
11

a. What is the mass number of sodium? ____________________

b. What is the atomic number of sodium? ____________________

c. How many protons does an atom of sodium has? ____________

d. How many electrons does an atom of sodium has? __________

e. How many neutrons does an atom of sodium has? ___________

# The Structure of an Atom.

**Objectives:**

- To explain the structure of an atom.

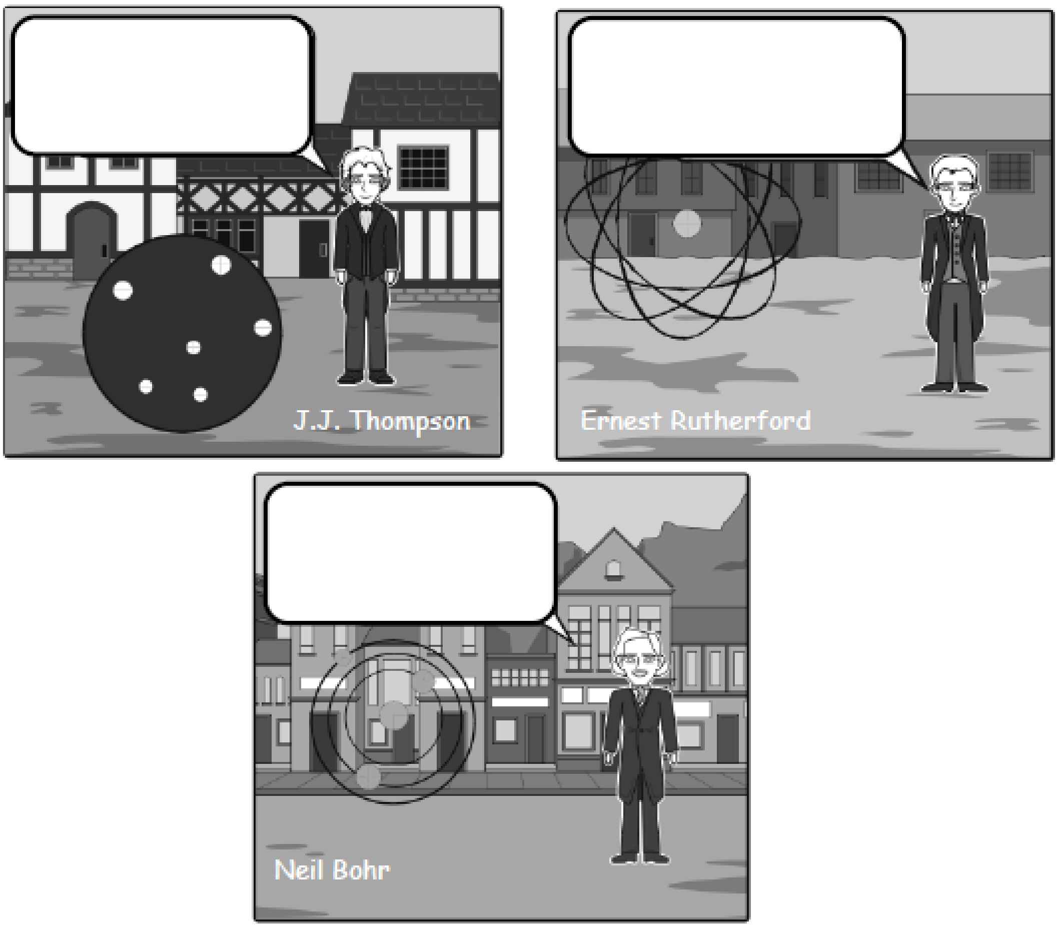
**1) Read the power point presentation: Atomic Theory: A Brief History Part 2**

2) **Watch the You-Tube video: Energy Levels and Electron Configuration | Chemistry for All | Fuse School:** https://www.youtube.com/watch?v=vfKF6DEhcos

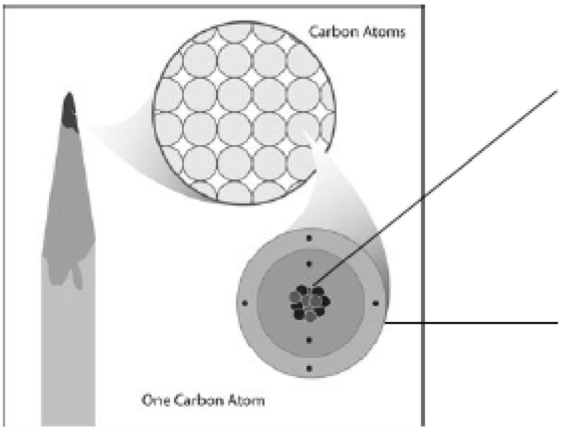
**3) Answer the following question:**

According to J.J. Thompson, Ernest Rutherford and Neil Bohr what does an atom look like?

(Write your answer in the bubbles below to complete this comic cartoon.)



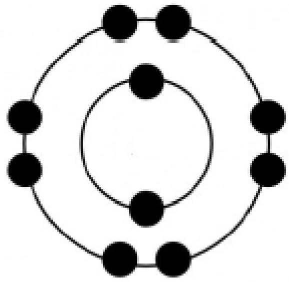
4) **Fill in the missing words in the diagram below:**




This is called the ________________ and it contains ________________ and ________________.

This is called an **electron shell** and it contains ________________.

5) **How many electrons are found in each shell?**



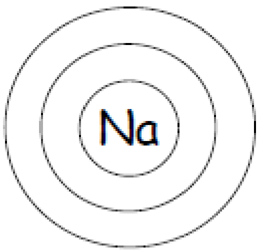
- Shell 1 holds ______________ electrons.
- Shell 2 holds ______________ electrons.
- The remaining electrons are then placed in the third shell.

6) **Work out the following example:**

Let us look at the sodium atom.
The mass number of a sodium atom is 23 and the atomic number is 11.
How many protons, neutrons and electrons are in a sodium atom?

No. of protons = ______ No. of neutrons = ______ No. of electrons = _______

Complete the diagram of a sodium atom by filling in the electrons in the electron shells.

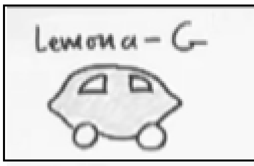


# Relative Atomic Mass (R.A.M) and Isotopes

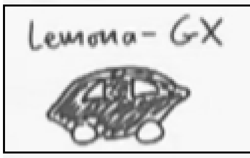
**Objectives:**

- To define the term isotopes.
- To work the amount of protons and neutrons in different isotopes.

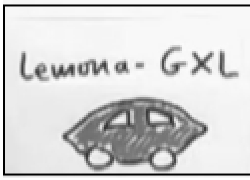
- Look at these 3 cars and at each of their features:




- It is yellow.
- It has a cd-player.
- It has leather seats.




- It is blue.
- It has a radio.
- It has massage seats.




- It is red.
- It has a television screen.
- It has velvet seats.

- All the three cars above have different features, that is, different colours, different seats etc….
- However all 3 cars are called Lemona since all 3 of them have the shape of a lemon.

- The same principle can be applied to atoms. Not all atoms of an element are exactly the same.
- For example when scientists examined Cl they found that there were 2 types of Cl:

$^{35}_{17}Cl$

Protons = ____________________

Neutrons = ___________________

$^{37}_{17}Cl$

Protons = ____________________

Neutrons = ___________________

- These two types of chlorine have the same number of _________________________ but different number of ___________________________.

- However, having the same number of protons, they are still atoms of chlorine. It's the number of protons which gives an element its identity.

- Atoms of the same element which have a different number of neutrons but the same number of protons are called ISOTOPES.

<u>Work out the number of protons and electrons these different isotopes have:</u>

1) $^{12}_{6}C$ Protons = ________ Neutrons = ________ $^{14}_{6}C$ Protons = ________ Neutrons = ________

2) $^{1}_{1}H$ Protons = ________ Neutrons = ________

$^{2}_{1}H$ Protons = ________ Neutrons = ________

$^{3}_{1}H$ Protons = ________ Neutrons = ________

3) $^{16}_{8}O$ Protons = ________ Neutrons = ________

$^{17}_{8}O$ Protons = ________ Neutrons = ________

$^{18}_{8}O$ Protons = ________ Neutrons = ________

You can revise what isotopes are by watching this You-Tube video:

What are Isotopes? | Chemistry | FuseSchool: https://www.youtube.com/watch?v=xjY5p-1CDr8&ytbChannel=FuseSchool%20-%20Global%20Education

# Ionic Bonding

**Objective:**

- To explain what happens when a metal bonds with a non-metal.

**Why do compounds form?**

- Write down the electronic configuration of Neon. ______________________
- To which group does Neon belong? ______________________
- What do we call the elements in this group? ______________________
- Why are the elements in this group so unreactive? ______________________

Therefore, why do atoms react? ______________________

Let's take a look at what happens when a **METAL** and a **NON-METAL** bond together.

**METAL - Sodium** + **NON-METAL - Chlorine**

| Draw a diagram of a sodium atom. | Draw a diagram of a chlorine atom. |
|---|---|
| | |

- How many electrons does sodium have in its outer shell? ____________
- How many electrons does chlorine have in its outer shell? ____________

What can sodium and chlorine do in order to react and be stable?

______________________

______________________

Check your answer by watching this You-Tube video: 3M2. Ionic Bonding Animation:
https://www.youtube.com/watch?v=Zdl0bNxQfco&ytbChannel=Rachel%20Matthews

## Covalent bonding

**Objective:**

- To explain what happens when a non-metal bonds with a non-metal.

Let's take a look at what happens when a **NON-METAL** and a **NON-METAL** bond.

**NON-METAL - Hydrogen** + **NON-METAL - Chlorine**

**Draw a diagram of a hydrogen atom.**

**Draw a diagram of a chlorine atom.**

- How many electrons does hydrogen have in its outer shell? ______________
- How many electrons does it need to get a full outer shell? ______________

- How many electrons does chlorine have in its outer shell? ______________
- How many electrons does it need to get a full outer shell? ______________

What can hydrogen and chlorine do in order to react and be stable?

________________________________________________________________

Watch this You-Tube video (till 1:45) in order to answer the question above:

What are covalent bonds | Chemistry for All | FuseSchool: https://www.youtube.com/watch?v=h24UmH38_LI&ytbChannel=FuseSchool%20-%20Global%20Education

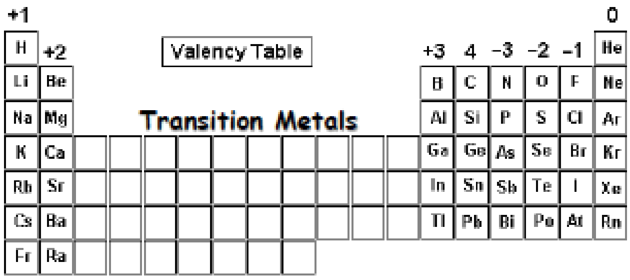
# Valency

**Objective:**

- To explain what valencies are and why they are useful.

## Should one remember the valencies of the most common elements?

Yes, however, there is some help. Usually the valency of the most common elements can be obtained from the Group they belong in the periodic table as shown below.




- The transition elements **do not have a group number** and therefore the valencies of the most common transition elements should be remembered.
- One must note also that transition elements have **more than one valency**.

| Element | Valency | Ion Formula | Ion name |
|---|---|---|---|
| Cu | +1 | $Cu^{+}$ | Copper (I) |
| | +2 | $Cu^{2+}$ | Copper (II) |
| Fe | +2 | $Fe^{2+}$ | Iron (II) |
| | +3 | $Fe^{3+}$ | Iron (III) |
| Ag | +1 | $Ag^{+}$ | Silver |
| Zn | +2 | $Zn^{2+}$ | Zinc |

**The valency is the number of electrons an atom has to lose, gain or share to attain a stable electronic structure.**

Watch the following You-Tube video in order to see why valencies are important:

Formulae of Ionic Compounds & their Names - Part 1 | The Chemistry Journey | The Fuse School https://www.youtube.com/watch?v=vfYnhnfdsD0&ytbChannel=FuseSchool%20-%20Global%20Education

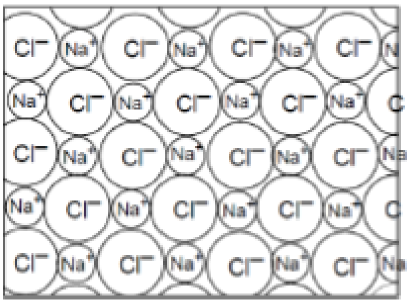
# Appendix 6

# IONIC BONDING TRUE OR FALSE

# EXERCISE

# Ionic Bonding
# – True or False?

The statements below refer to the diagram of the structure of sodium chloride. The diagram shows part of a slice through the three dimensional crystal structure.



Please read each statement carefully, and decide whether it is correct or not.

| | | True | False |
|---|---|---|---|
| 1. | A positive ion will be attracted to any negative ion. | | |
| 2. | A sodium ion is only bonded to the chloride ion it donated its electron to. | | |
| 3. | A sodium atom can only form one ionic bond, because it only has one electron in its outer shell to donate. | | |
| 4. | The reason a bond is formed between chloride ions and sodium ions is because an electron has been transferred between them. | | |
| 5. | In the diagram each molecule of sodium chloride contains one sodium ion and one chloride ion | | |
| 6. | An ionic bond is the attraction between a positive and a negative ion. | | |
| 7. | A positive ion can be bonded to any neighbouring negative ion, if it is close enough. | | |
| 8. | An ionic bond is when one atom donates an electron to another atom, so they both have full outer shells. | | |
| 9. | There are no molecules shown in the diagram. | | |

Adapted from: Taber, K. (2002). Chemical misconceptions—prevention, diagnosis and cure. London: Royal Society of Chemistry.

# Appendix 7

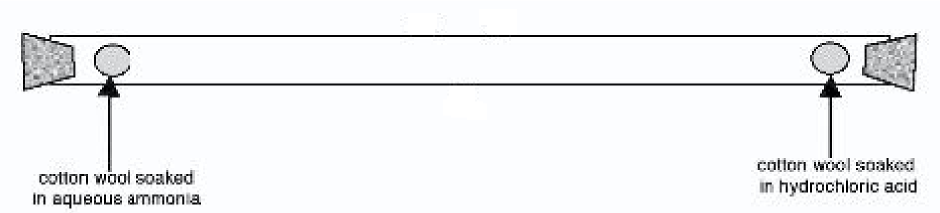
# STUDENTS' CLASSWORK PACK

# NATURE OF MATTER, ATOMIC STRUCTURE AND CHEMICAL BONDING

Classwork

## How can you prove that particles really exist?

1) Look at the apparatus below:




- Where will the ammonia particles and hydrogen chloride particles meet?

Mark your answer with an X on the diagram above. Give a reason for your answer.

______________________________________________

______________________________________________

- What will you see when the hydrogen chloride particles and the ammonia particles meet? Give an explanation for this result.

______________________________________________

______________________________________________

- The movement of gas particles from a region of high concentration to a region of low concentration is called ____________________.

## More evidence which shows the existence of particles.

As you know, the particles in solids, liquids and gases can't be seen under a microscope. However, you see some effects of the particles using a microscope.

1) In 1827, Robert Brown noticed pollen grains jiggling about in water when placed under a microscope. Why did this happen?

______________________________________________

______________________________________________

2) Dust particles in the air can also be seen moving about randomly. Why?

______________________________________________

______________________________________________

3) The rapid, random movement of particles which collide and bump into each other and bounce off in all directions is called ______________________________.

## What are atoms made up of?

Based on the given information and **WITHOUT** using a periodic table, complete the following exercises:

**Exercise 1:**

| Element | Symbol | Atomic number | Mass number | Number of electrons | Number of protons | Number of neutrons |
|---|---|---|---|---|---|---|
| hydrogen | | 1 | 1 | | | |
| | Ne | 10 | 20 | | | |
| | K | | | | 19 | 20 |
| magnesium | | 12 | 24 | | | |
| oxygen | | 8 | | | | 8 |
| | Na | 11 | | 11 | | 12 |
| Carbon | | | | | 6 | 6 |

**Exercise 2:**

| Element | Symbol | Atomic number | Mass number | Number of electrons | Number of protons | Number of neutrons |
|---|---|---|---|---|---|---|
| | Li | 3 | 7 | | | |
| Phosphorus | | 15 | 31 | | | |
| Helium | | | 4 | 2 | | |
| | Ni | 28 | | | | 31 |
| Beryllium | | | 9 | | | 5 |
| Silver | | 47 | | | | 61 |
| Silicon | | | | | 14 | 14 |
| | Ca | | 40 | 20 | | |
| | I | | 127 | | | 74 |
| | Fe | | | | 26 | 30 |

# The Structure of an Atom

**Work out the following examples:**

1. Magnesium's atomic number is 12. Its mass number is 24.

A) How many protons, neutrons and electrons are there in a magnesium atom?

Number of protons = ______ number of neutrons = ______ number of electrons = _____

B) What is the **electronic configuration** of magnesium? _________________

C) Draw a diagram of a magnesium atom.

**Magnesium atom**

2. Oxygen's atomic number is 8. Its mass number is 16.

A) How many protons, neutrons and electrons are there in an oxygen atom?

Number of protons = ______ number of neutrons = ______ number of electrons = _____

B) What is the **electronic configuration** of oxygen? _________________

C) Draw a diagram of an oxygen atom.

**Oxygen atom**

3. Neon's atomic number is 10. Its mass number is 20.

A) How many protons, neutrons and electrons are there in a neon atom?

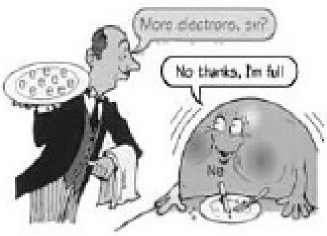
Number of protons = ______ number of neutrons = ______ number of electrons = _____

B) What is the **electronic configuration** of neon? _______________

C) Draw a diagram of a neon atom.

| Neon atom |
|---|
| |

- How many electrons are there in Neon's outer shell? ________.
- Is this a full shell? __________.
- The elements in group 8 or 0 of the periodic table are called the **noble gases**. These elements are very stable, in fact they hardly react. Can you suggest why?




______________________________________________

**<u>Complete the following exercises on a separate sheet of paper:</u>**

**Exercise 1:** Draw the atomic structures (showing all the electron shells) and write the electronic configuration of the following atoms:

A) lithium B) aluminium

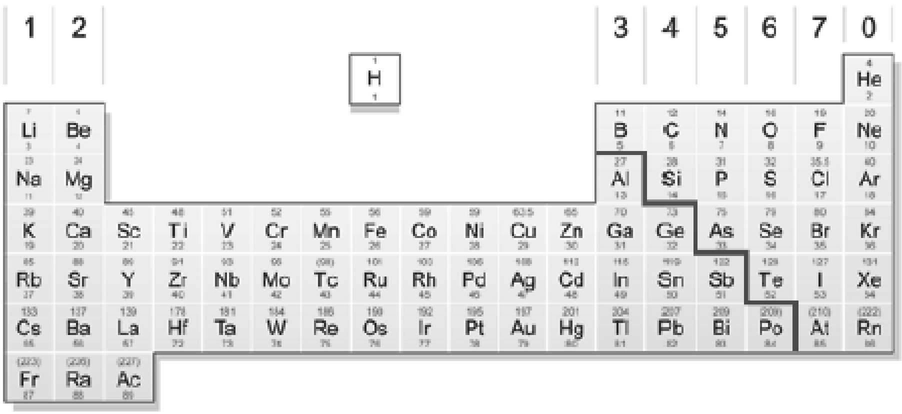
C) calcium D) silicon

**Exercise 2:** Draw the atomic structures (showing outer electron shells only) and write the electronic configuration of the following atoms:

A) beryllium B) phosphorus

C) potassium D) argon

## Predicting if an atom represents a metal, a non-metal or a noble gas




Look at the periodic table. Look at the zig-zag through the groups. It separates the ________________ from the ________________. The ______________ are on the left while the ________________ are on the right of the periodic table. The elements in groups 1, 2 and 3 tend to be _______________ because their atoms have 1, 2 or 3 electrons in their outer shells. Elements on the right hand side, that is Group 5, 6, 7 and 8 (or 0) are _________________ as their atoms have 5, 6, 7 or 8 electrons in their outer shell. Group 4 contains both _______________ and _________________. The elements in group 8 or 0 are called the ______________________ and their atoms have _______ electrons in their outer shells.

**Work out this exercise:**

| Element | Atomic number | Electronic configuration | Metal, non-metal or noble gas |
|---|---|---|---|
| $^{7}_{3}Li$ | 3 | 2, 1 | metal |
| $^{16}_{8}O$ | | | |
| $^{27}_{13}Al$ | | | |
| $^{40}_{18}Ar$ | | | |
| $^{23}_{11}Na$ | | | |
| $^{35.5}_{17}Cl$ | | | |
| $^{4}_{2}He$ | | | |
| $^{14}_{7}N$ | | | |

# Relative Atomic Mass (R.A.M) and Isotopes

**Worked example: Finding the Relative Atomic Mass (R.A.M) of an element.**

**E.g. Chlorine**

| | | |
|---|---|---|
| **Isotopes:** | $^{35}_{17}Cl$ | $^{37}_{17}Cl$ |
| **Relative abundance:** | 75% | 25% |

$$\frac{(75 \times 35) + (25 \times 37)}{100} = 35.5$$

**Work out the following questions:**

A. $^{107}_{47}Ag$ B. $^{109}_{47}Ag$

1. Silver is an element which exists naturally as a mixture of two isotopic forms. A and B represent these two isotopes. They occur in nature in equal numbers. Calculate the relative atomic mass of silver.

2. An element Z has 3 isotopes. These are $^{29}_{16}Z$, $^{31}_{16}Z$ and $^{33}_{16}Z$. The relative abundance of each isotope is 52%, 28% and 20% respectively. Calculate the relative atomic mass of Z.

3. Element A has 2 isotopes. These are $^{18}_{11}A$ and $^{20}_{11}A$. The relative abundance of $^{18}_{11}A$ is 73% while that of isotope $^{20}_{11}A$ is 27%. Calculate the relative atomic mass of A.

4. The element Boron exists as two different atoms, $^{10}_{5}B$ and $^{11}_{5}B$. A sample of Boron contains 20% of $^{10}_{5}B$ and 80% of $^{11}_{5}B$.

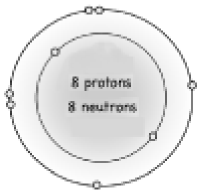
A. Complete the following table.

| Atom | Number of protons | Number of neutrons |
|---|---|---|
| $^{10}_{5}B$ | | |
| $^{11}_{5}B$ | | |

B. Calculate the relative atomic mass of Boron, using the information provided.

6. The following diagram shows an atom of $^{16}_{8}O$. Draw the other two isotopes of oxygen: $^{17}_{8}O$ and $^{18}_{8}O$.

Oxygen-16




$^{16}O$

7. Atom A has an atomic number of 82 and mass number 204. Atom B has an atomic number 80 and mass number 201.

A. How many protons are there in atom A? ____________________

B. How many protons are there in atom B? ___________________

C. Are atoms A and B isotopes of the same element? Explain your answer.

______________________________________________________________

______________________________________________________________

**It is important to distinguish between relative atomic mass and mass number:**

**Relative atomic mass**: the average mass of an atom of an element based on the relative natural abundance of that element's isotopes.

**Mass number**: a count of the total number of protons and neutrons in an atom's nucleus.

## Ionic Bonding

**Ionic Bonding always occurs between a METAL and a NON-METAL.**

- The atoms of some elements can obtain full shells by losing or gaining electrons, when they react with other atoms. Let us look at sodium chloride as an example.

**Draw a diagram of a sodium atom.**

**Draw a diagram of a chlorine atom.**

- Both atoms want to be stable by having full outer shells. They will always take the easiest way to fill their outer shell electrons.

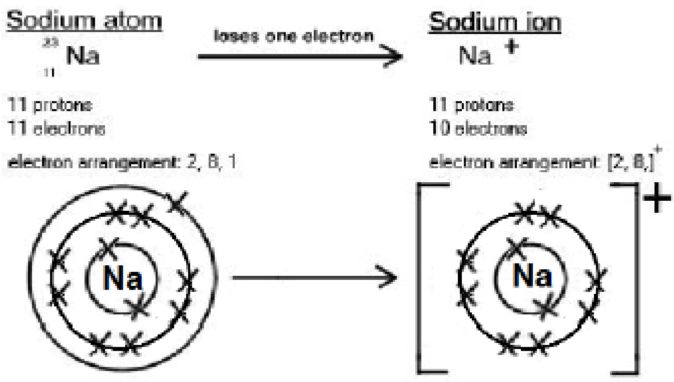
Notice that sodium has _____ electron/s in its outer shell. How could it get a full outer shell? Would it be easier for sodium to lose just 1 electron, or to gain 7 electrons?

_______________________________________________

Now look at the chlorine atom above. It has _____ electron/s in its outer shell. How could it get a full outer shell? Would it be easier for chlorine to lose 7 electrons, or to gain just 1? _______________________________________________

## Metals lose their outer shell electrons

- When sodium loses it's outer electron it forms an **ion.**
- If you remember atoms are neutral because the number of protons and electrons are equal.
- However, **ions are not neutral and so carry a charge.**




Sodium atom - Electron ——→ Sodium ion

Na - $e^-$ ——→ $Na^+$

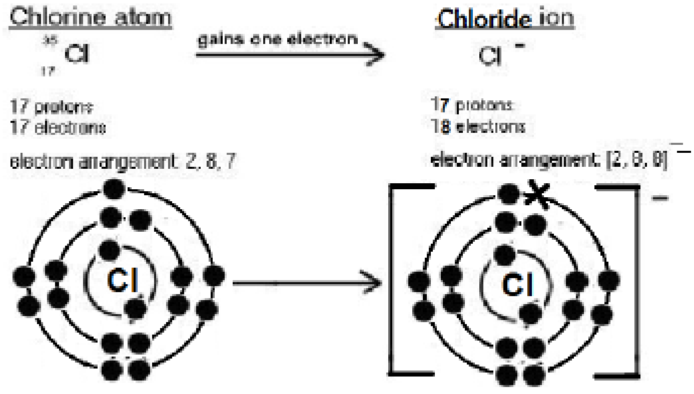
- A sodium atom has _______ protons and ________ electrons,
- A sodium ion has ________ protons and ________ electrons.

| The charge on the sodium **atom**: | The charge on the sodium **ion**: |
|---|---|
| Add up the charges | Add up the charges |
| _______ protons = ___________ | _______ protons = ___________ |
| _______ electrons = __________ | _______ electrons = __________ |
| Overall charge = __________ | Overall charge = __________ |

- The symbol for a sodium atom is ________, and that of a sodium ion is ___________.
- The + means 1 positive charge. $Na^+$ is a positive ion. **A positively charged ion is called a** _________________________.

## Non-metals gain electrons

- When chlorine gains an electron it also forms an **ion**.




Clorine atom + Electron ⟶ Chloride ion

$Cl$ + $e^-$ ⟶ $Cl^-$

- A chlorine atom has _______ protons and ________ electrons.
- A chloride ion has _______ protons and ________ electrons.

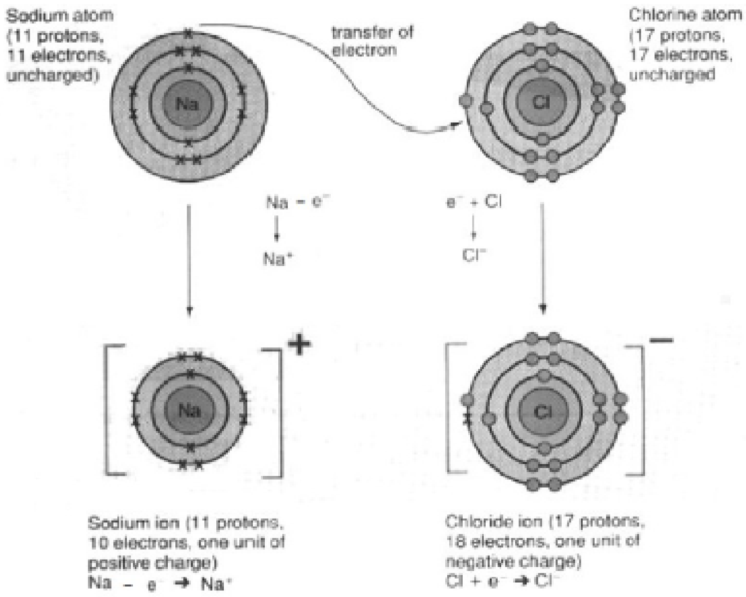
| The charge on the chlorine atom: | The charge on the chloride ion: |
|---|---|
| Add up the charges | Add up the charges |
| _______ protons = ____________ | _______ protons = ____________ |
| _______ electrons = ___________ | _______ electrons = ___________ |
| Overall charge = ___________ | Overall charge = ___________ |

- The symbol for a chlorine atom is ________, and that of a chloride ion is ________.
- The - means 1 negative charge. $Cl^-$ is a negative ion. A negatively charged ion is called an _______________.

**An ion is a charged particle. It is charged because it contains an unequal number of protons and electrons. The charge is equal to the number of electrons gained or lost.**

**Summary:**

- When sodium reacts it ______________ its outer shell electron. Therefore, sodium becomes ______________ charged.
- Chlorine _____________ an electron. Therefore, chlorine becomes _____________ charged.




- Look at the diagram above. Here sodium electrons are shown as X and chlorine as •. This is called a **dot-and-cross diagram**.

- The two ions have opposite charges, so they attract each other. The force of attraction between them is strong. It is called an **ionic bond** or sometimes an **electrovalent bond**. Millions of ions bond together to form crystals.

- When sodium and chlorine react together, each sodium atom gives ____ electron/s to each chlorine atom. The atoms 'satisfy' each other one-to-one. So the formula of sodium chloride is ____________.

**Ionic bonding is the electrostatic attraction between oppositely charged ions.**

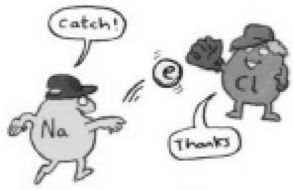
**Ions may be formed when metals lose electrons to become positively charged while non-metals gain electrons to become negatively charged.**

## Work out the following exercises on a separate sheet of paper:

**Exercise 1:**

*Draw a dot-and-cross diagram showing the formation of the following ionic compounds. (Show all the electrons of the atoms/ions). Include the electronic configuration of the ions and the formula of the compound.*

1) Magnesium Chloride
2) Sodium oxide
3) Magnesium oxide
4) Lithium sulfide



Metal atoms give electrons to non-metal atoms

**Exercise 2:**

*Draw a dot-and-cross diagram showing the formation of the following ionic compounds. (Show only the outer shell electrons of the atoms/ions.) Include the electronic configuration of the ions and the formula of the compound.*

1) Lithium fluoride
2) Calcium oxide
3) Magnesium chloride
4) Potassium chloride

**Exercise 3:**

*Draw a dot-and-cross diagram showing the formation of the following ionic compounds. (Show all the electrons of the atoms/ions). Include the electronic configuration of the ions and the formula of the compound.*

1) Lithium oxide
2) Sodium sulfide
3) Aluminum chloride

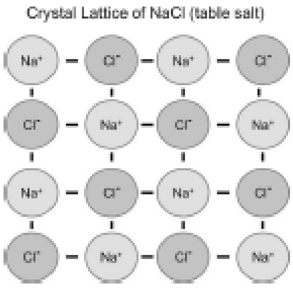
**Exercise 4:**

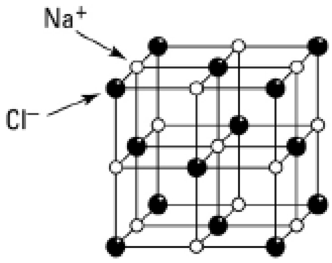
*Draw a dot-and-cross diagram showing the formation of the following ionic compounds. (Show only the outer shell electrons of the atoms/ions.) Include the electronic configuration of the ions and the formula of the compound.*

1) Aluminium oxide
2) Magnesium nitride
3) Potassium sulfide

**Properties of ionic compounds:**

1) They have high melting points and boiling points.
2) The oppositely-charged ions are arranged in a regular way to form a giant ionic lattice. As a result ionic compounds form crystals.




3) They conduct electricity when molten or dissolved in water. They do not conduct electricity when they are solids.
4) Ionic compounds are usually soluble in water.

## Covalent bonding

- ***Covalent Bonding always occurs between a NON-METAL and a NON-METAL.***
- ***When non-metals SHARE their outer shell electrons, MOLECULES form.***

**1. Fluorine, $F_2$**

What is the electronic configuration of F? ____________________

Therefore how many electrons does each fluorine atom need to have full shell? ________

Draw a fluorine molecule showing all the electron shells.

- The same bonding is present in the following substances:

hydrogen $H_2$, oxygen $O_2$, nitrogen $N_2$, fluorine $F_2$, bromine $Br_2$ and iodine $I_2$.

- These are called **diatomic molecules** because each molecule is made up of two atoms.

**2. Chlorine, $Cl_2$**

What is the electronic configuration of Cl? ______________________

Therefore how many electrons does each chlorine atom need to have full shell? ________

Draw a chlorine molecule showing all the electron shells.

**3. Bromine, $Br_2$**

How many electrons does Bromine have in its outer shell? ____________

Therefore how many electrons does each bromine atom need to have full shell? ________

Draw a bromine molecule showing the outer electron shells only.

**4. Iodine, $I_2$**

How many electrons does Iodine have in its outer shell? _____________

Therefore how many electrons does each iodine atom need to have full shell? ________

Draw an iodine molecule showing the outer electron shells only.

**5. Hydrogen, $H_2$**

What is the electronic configuration of H? ________________________

Therefore how many electrons does each hydrogen atom need to have full shell? _______

Draw a hydrogen molecule showing all the electron shells.

**6. Oxygen, $O_2$**

What is the electronic configuration of O? ________________________

Therefore how many electrons does each oxygen atom need to have full shell? ________

Draw an oxygen molecule showing all the electron shells.

**7. Nitrogen, $N_2$**

What is the electronic configuration of N? ________________________

Therefore how many electrons does each nitrogen atom need to have full shell? _______

Draw a nitrogen molecule showing all the electron shells.

**8. Hydrogen chloride HCl**

- A molecule of hydrogen chloride is made up of hydrogen and chlorine atoms.
- Chlorine has ___ electrons in its outer shell. It needs _____ electron/s to fill its shell.
- Hydrogen has just _____ electron. It needs _____ electron/s to fill its shell.
- Therefore each chlorine atom needs to share ______ electron with ______ hydrogen atom/s. In this way they will all reach full shells.

**9. Water $H_2O$**

- A water molecule is made up of ______________ and ______________ atoms.
- Hydrogen has just ______ electron in its outer shell. It needs ______ electron to fill its shell.
- Oxygen has ________ electrons in its outer shell. It needs _______ electrons to fill its outer shell.
- Therefore each oxygen atom needs to share electrons with ________ hydrogen atoms. In this way they will all reach full shells.

**10. Ammonia $NH_3$**

- A molecule of ammonia is made up of nitrogen and hydrogen atoms.
- Nitrogen has _______ electrons in its outer shell. It therefore needs ________ electron/s to fill its shell.
- Hydrogen has just 1 electron. It needs ____ electron/s to fill its shells.
- Therefore each nitrogen needs to share electrons with ________ hydrogen atom/s. In this way they will all reach full shells.

**11. Methane, $CH_4$**

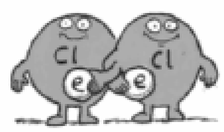
- A molecule of methane is made up of carbon and hydrogen atoms.
- Carbon has ______ electrons in its outer shell. It needs _____ electron/s, to fill its shell.
- Therefore each carbon atom needs to share electrons with ______ hydrogen atoms. In this way they will all reach full shells.

**12. Carbon dioxide, $CO_2$**

- A molecule of carbon dioxide is made up of carbon and oxygen.
- Carbon has _______ electrons in its outer shell. It needs _______ electron/s, to fill its outer shell.
- Therefore the carbon atom shares 2 electrons with each of the 2 oxygen atoms. Each oxygen atom shares 2 of its electrons with the carbon atom. In this way 2 pairs of electrons are shared between the carbon atom and each oxygen. Each C=O bond is called a double bond.

## Properties of covalent compounds:

1) They have low melting points and boiling points.
2) They consist of small molecules.
3) They do not conduct electricity.



Chlorine atoms share a pair of electrons in a covalent bond

## Revision questions

1. Draw a diagram, showing only the outer electrons, to illustrate the bonding in the following compound: $CCl_4$.

2. *Astatine*, *At*, is an element with 7 electrons in its outer shell while *Caesium*, *Cs*, is an element with 1 electron in its outer shell. What type of bonding would you predict in *Caesium astatide*? Draw a dot-and-cross diagram to show the bonding. (show outer shell electrons only.)

3. Radium, Ra, is an element with 2 electrons in its outer shell, and iodine, I, is an element with 7 electrons in the outer shell. What type of bonding would you predict for radium iodide? Draw a dot-and-cross diagram to show your reasoning. (show outer shell electrons only.)

4. Atoms of three elements, *A*, B and *C* have 8, 9 and 11 electrons respectively.

A. Determine the most likely compound formed by the combination of:

i) Elements *A* and *C*. ______________________________

ii) Elements B and *C*. ______________________________

iii) Atoms of element *A* with each other. ____________________

B. In each of the cases (i) - (iii) name the type of bond formed.

______________________

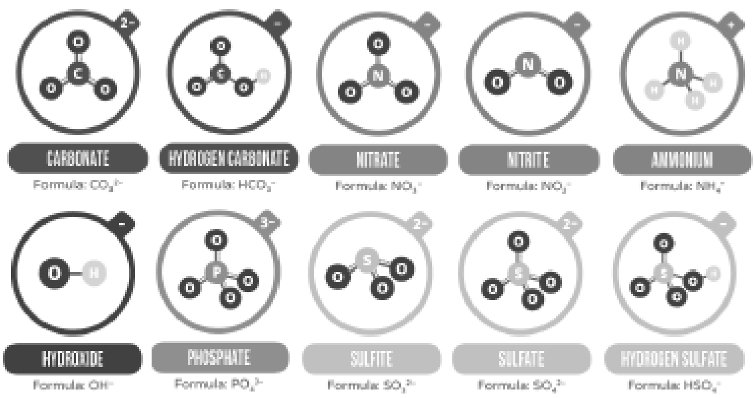
______________________

______________________

## Polyatomic ions and their valencies

**A polyatomic ion is an ion made up of more than one type of atom joined together.**

| Polyatomic ion | Symbol | Polyatomic ion | Symbol |
|---|---|---|---|
| sulfate | $SO_4^{2-}$ | carbonate | $CO_3^{2-}$ |
| sulfite | $SO_3^{2-}$ | hydrogen carbonate | $HCO_3^{-}$ |
| nitrate | $NO_3^{-}$ | hydrogen sulfate | $HSO_4^{-}$ |
| nitrite | $NO_2^{-}$ | phosphate | $PO_4^{3-}$ |
| hydroxide | $OH^{-}$ | ammonium | $NH_4^{+}$ |



# Chemical Formulae

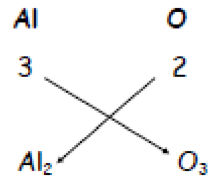
There is a very simple method of writing chemical formulae. These can be worked out if the appropriate symbols and valencies, of the elements or polyatomic ions forming the compound, are known.

**Worked example:** Write the formula of Aluminium oxide.

1. Write down the symbols involved, putting the metal (element nearer to the left of the periodic table) first, and leaving a small gap between them:

**Al** **O**

2. Obtain the valencies of both elements and swap them (cross them over) so that the valency of the first element is placed after the symbol of the second element, and similarly, the valency of the second element is written after the first symbol.

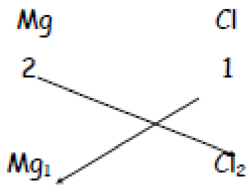



Thus the chemical formula is: $Al_2O_3$.

**Some rules:**

1) **One must note that is there are elements with a valency of 1, it is not necessary to write down the number 1 in the chemical formula.**

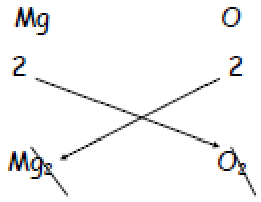
So for example, the formula for magnesium chloride is worked out as follows: Magnesium has a valency of 2, and chlorine has a valency of 1.




By crossing over the valencies **the formula is $MgCl_2$** and not $Mg_1Cl_2$.

2) **When the two valencies are equal, they cancel each other out since the ratio of atoms would be 1:1.**

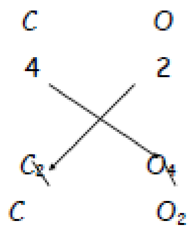
For example in magnesium oxide, magnesium has a valency of 2 and also oxygen has a valency of 2.




So **the formula is MgO** and not $Mg_2O_2$.

3) **If the valencies have a lowest common multiple, then the smallest ratios are written down.**

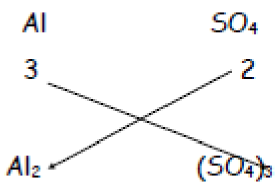
For example, in carbon dioxide, carbon has a valency of 4, while oxygen has a valency of 2. So the ratio C:O is 2:4, and the simplest ratio is 1:2.




Hence **the formula of carbon dioxide is $CO_2$** and not $C_2O_4$.

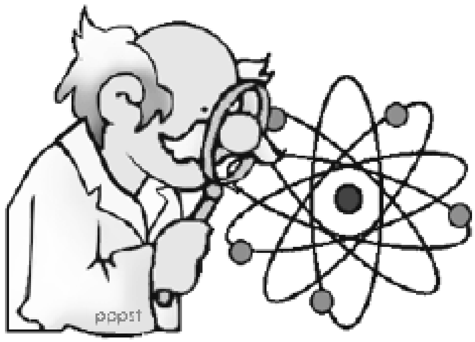
4) **If one or more polyatomic ions are present, they must be considered as one entity and not as separate atoms. So brackets may be needed so as to avoid confusion between any numbers already present and those numbers being added.**

For example, in aluminium sulfate, aluminium has a valency of 3, and the sulfate ion has a valency of 2. By crossing over valencies it would be wrong to write $Al_2SO_{43}$. Instead, the correct formula is $Al_2(SO_4)_3$.

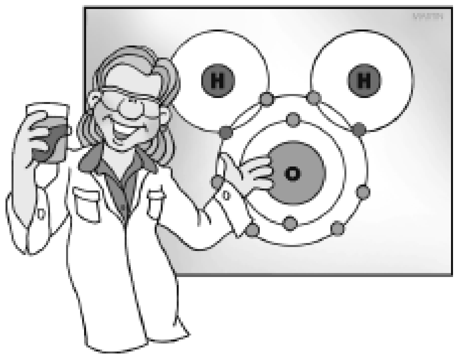


**Work out the chemical formulae for the following compounds on a separate sheet of paper:**

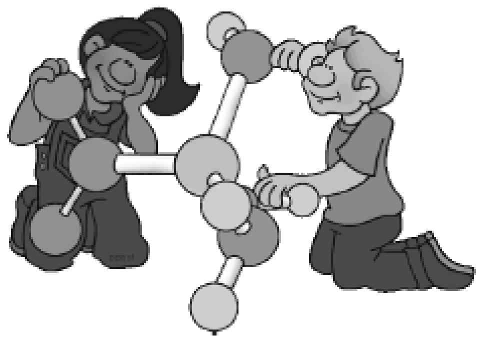
1. Potassium nitrate
2. Calcium hydrogen carbonate
3. Barium hydroxide
4. Ammonium bromide
5. Aluminium phosphate
6. Magnesium nitrite
7. Copper (II) nitrate
8. Zinc sulfate



9. Ammonium sulfide
10. Calcium oxide
11. Sodium sulfate
12. Iron (II) sulfite
13. Magnesium phosphate
14. Aluminium carbonate
15. Calcium chloride
16. Zinc nitrate
17. Copper (II) hydroxide
18. Sodium sulfite




19. Silver chloride
20. Barium bromide
21. Barium nitrate
22. Ammonium sulfate
23. Magnesium fluoride
24. Copper (II) iodide
25. Aluminium oxide
26. Iron (II) oxide
27. Iron (III) sulfate
28. Iron (III) sulfide
29. Silver nitrate
30. Aluminium chloride



# Appendix 8

# STUDENTS' REFLECTIVE JOURNAL

Date: ___________________________

1) How long did you take to carry out the tasks the teacher assigned to the class in order to prepare for the lesson whilst at home? ________

2) Give a brief overview of what you learned from the tasks at home and at school.

_________________________________________________________

_________________________________________________________

_________________________________________________________

_________________________________________________________

3) What difficulties / questions do you have regarding the content of the topic?

_________________________________________________________

_________________________________________________________

_________________________________________________________

4) Did these difficulties crop up whilst doing the tasks at home or at school? Did your teacher answer these questions? If not, why?

_________________________________________________________

_________________________________________________________

_________________________________________________________

5) How did you feel whilst doing the tasks **<u>at home</u>**?

Some points to help you answer the question:

- Did you enjoy doing it or not? Why?
- Did you feel that the tasks were too difficult for you or did you do them with very little difficulty? Why?

_________________________________________________________

_________________________________________________________

_________________________________________________________

_________________________________________________________

_________________________________________________________

6) How did you feel whilst doing the tasks **at school**?

Some points to help you answer the question:

- Did you enjoy doing it or not? Why?
- Did you feel that the tasks were too difficult for you or did you do them with very little difficulty? Why?

________________________________________________________

________________________________________________________

________________________________________________________

________________________________________________________

________________________________________________________

7) Any other comments?

________________________________________________________

________________________________________________________

# Appendix 9

# FOCUS GROUP QUESTIONS

**Introduction:**

First of all, thank you for accepting to participate in my research regarding the teaching and learning of Chemistry. Thank you also for offering 30 minutes of your time in order to participate in this group discussion. I would like to remind you that your voice will be recorded. However, your identity will not be revealed.

**Questions:**

1. How did you feel about the fact that before dealing with a new task, the teacher gave you some preparation work to do at home?
    - Did you find most of tasks easy or difficult to follow? Which tasks were the most difficult to carry out and why?
    - What did you do if you encountered a difficulty at home?
    - Did you spend a lot of time on the tasks? If yes, why?
    - Did the videos help you understand the new concepts? Why?
    - When answering questions from the homework pack did you quote from the videos or did you use your own words in order to explain certain things? Why?
    - Did you watch the videos once or more than once? Why?
    - Did you watch the video at one go or did you pause/ stop the video several times? Why?
    - Did you use sub-titles to watch the video or not? Why?

2. When you went to class did you feel that the work done at home helped you understand the topics done in class or not?
    - If you missed one lesson, were you able to catch up with the others?
    - If you missed more than one lesson, were you able to catch up?
    - What did you do whenever you missed a lesson? Did you ask for the homework that needed to be done for the next lesson? Why?

3. Whilst in class you were given a lot of tasks to complete in groups.
    - Did you enjoy working in groups? Why?

- What did you usually do whilst working together? How did you tackle the given exercises?
- What happened when you or one of your friends who you were working with had a problem? How did you solve it?

4. How did you feel when during these lessons you were asked to participate such as in whole class discussions and group work and not simply sit down and listen to teacher explain? Do you enjoy these type of lessons or do you prefer to sit down, listen and simply follow the lesson? Why?

5. Do you think that homework is important? Why?
   - Should teachers give homework to students?
   - What do you prefer:
     - → Homework as a means of preparation for the next lesson and revision exercises to work at school; or
     - → Homework in order to revise topics done at school and no preparation homework for the next lesson. Why?
   - How much time do you normally spend at home in order to revise chemistry per week?
   - If you were not given any kind of homework, would you spend more time studying or not?

6. To conclude, after going through the lessons about the topic 'Nature of Matter, Atomic Structure and Chemical Bonding', do you feel that you have understood the content well or do you feel that you still have some difficulties? Why?
   - Which tasks do you feel confident in?
   - Which tasks are you not confident in? Why?
   - Which task did you feel most challenging? Why?
   - Which task did you enjoy doing the most? Why?
   - Do you recommend this method of teaching and learning to other teachers? Why?

# Appendix 10

# LIKERT-SCALE QUESTIONNAIRE

# Questionnaire

**Please tick accordingly:** Male: ☐ Female:☐

*Below are a number of statements about your experience when learning the topic: 'Nature of Matter, Atomic Structure and Chemical Bonding'. Please read each one and indicate to what extent you agree or disagree with each statement by circling the correct number.*

| | | Strongly Agree | Agree | Slightly Agree | Slightly Disagree | Disagree | Strongly Disagree |
|---|---|---|---|---|---|---|---|
| 1) | I liked the fact that my teacher gave me tasks to do before the lesson rather than after the lesson. | 6 | 5 | 4 | 3 | 2 | 1 |
| 2) | I feel that the tasks completed at home before the lesson helped me prepare myself more for the upcoming lesson. | 6 | 5 | 4 | 3 | 2 | 1 |
| 3) | I prefer being given tasks after the lesson (about the content done during the lesson) rather than before. | 6 | 5 | 4 | 3 | 2 | 1 |
| 4) | I think that a new topic should be first dealt with at school rather than first introduced when alone at home. | 6 | 5 | 4 | 3 | 2 | 1 |
| 5) | I think homework is useless whether it is given before or after the lesson. | 6 | 5 | 4 | 3 | 2 | 1 |
| 6) | I found the tasks given at home too difficult for me. | 6 | 5 | 4 | 3 | 2 | 1 |

| | | Strongly Agree | Agree | Slightly Agree | Slightly Disagree | Disagree | Strongly Disagree |
|---|---|---|---|---|---|---|---|
| 7) | I always completed all the tasks given by the teacher. | 6 | 5 | 4 | 3 | 2 | 1 |
| 8) | I spent a lot of time to complete the tasks at home. | 6 | 5 | 4 | 3 | 2 | 1 |
| 9) | Whenever I was given a video to watch, I used to stop/pause it in order to understand better. | 6 | 5 | 4 | 3 | 2 | 1 |
| 10) | I used to watch the given videos more than once. | 6 | 5 | 4 | 3 | 2 | 1 |
| 11) | I liked the fact that the tasks involved some technological aspect such as watching videos online. | 6 | 5 | 4 | 3 | 2 | 1 |
| 12) | The videos assigned by the teacher were too difficult to understand. | 6 | 5 | 4 | 3 | 2 | 1 |
| 13) | The videos assigned by the teacher were too long. | 6 | 5 | 4 | 3 | 2 | 1 |
| 14) | After watching the video that was assigned to me by my teacher I used to watch other related videos. | 6 | 5 | 4 | 3 | 2 | 1 |
| 15) | I feel that I learn a lot through videos. | 6 | 5 | 4 | 3 | 2 | 1 |
| 16) | I understood the content of this topic. | 6 | 5 | 4 | 3 | 2 | 1 |
| 17) | I liked the fact that we worked a lot of exercises in order to practise at school. | 6 | 5 | 4 | 3 | 2 | 1 |

| | | Strongly Agree | Agree | Slightly Agree | Slightly Disagree | Disagree | Strongly Disagree |
|---|---|---|---|---|---|---|---|
| 18) | I enjoyed working out tasks in groups with my friends at school. | 6 | 5 | 4 | 3 | 2 | 1 |
| 19) | I enjoyed explaining what I learned to my classmates during the lesson. | 6 | 5 | 4 | 3 | 2 | 1 |
| 20) | The teacher helped me whenever I had a difficulty. | 6 | 5 | 4 | 3 | 2 | 1 |
| 21) | The teacher gave me feedback on my work and so I knew what I was doing right or what needed improvement. | 6 | 5 | 4 | 3 | 2 | 1 |
| 22) | I feel confident working out questions related to this topic on my own. | 6 | 5 | 4 | 3 | 2 | 1 |
| 23) | I know how to study on my own at home. | 6 | 5 | 4 | 3 | 2 | 1 |
| 24) | I enjoyed learning this topic. | 6 | 5 | 4 | 3 | 2 | 1 |
| 25) | I would like other teachers to use this teaching method. | 6 | 5 | 4 | 3 | 2 | 1 |
| 26) | I participated willingly during the lesson. | 6 | 5 | 4 | 3 | 2 | 1 |
| 27) | I prefer to sit and listen to the teacher talk rather than participate in the lesson. | 6 | 5 | 4 | 3 | 2 | 1 |

# Appendix 11

# END-OF-TOPIC TEST

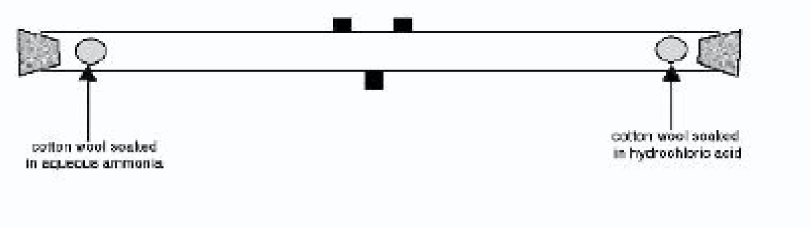
| |
|---|
| |
| 50 |

Name: ______________________________ Class: ____________________

# Nature of Matter, Atomic Structure and Chemical Bonding Test

## Answer all the questions. Use your periodic table.

1. Philip set up the following apparatus in the school lab. After some time a white cloud was seen to form in the tube.




A) Mark with an X the point at which the white cloud was formed. Explain your answer.

______________________________________________________________________

______________________________________________________________________( 3 marks)

B) What is the name of the compound that formed in the tube?

______________________________________________________________________(1 mark)

C) What is the name of the process by which gases move from one place to another?

______________________________________________________________________(1 mark)

2. Diane was reading a book on the couch opposite her bedroom's window. A ray of sunlight was entering the room and Diane observed many dust particles moving around randomly in the air.

A) How did the dust particles move about randomly on their own?

______________________________________________________________________

______________________________________________________________________(2 marks)

B) What is the name of this process called? ______________________________ (1 mark)

3. A) Draw an oxygen atom and show its FULL structure. Label its different parts.

(5 marks)

B) Why is an oxygen atom neutral?

____________________________________________________________________

______________________________________________________________(2 marks)

4. Imagine that an atom has 19 protons and 20 neutrons.

A) How many electrons will it have? ________________

B) What would its mass number be? ________________

C) What would its atomic number be? ________________

D) What would its electronic configuration be?_________________

E) In which group of the periodic table will you find this element? __________________

F) Will it be a metal or a non-metal?__________________________

(6 marks)

5. Neon has 3 isotopes: $^{20}Ne$, $^{21}Ne$ and $^{22}Ne$. Their percentage abundance is 90.48%, 0.27% and 9.25% respectively.

A) Define the term isotope.

____________________________________________________________________

______________________________________________________________( 2 marks)

B) Calculate the R.A.M. of neon.

(3 marks)

6. A) Give the formulae of the following compounds:

| | |
|---|---|
| magnesium sulfate = | iron (II) hydroxide = |
| silver bromide = | zinc nitrate = |

(4 marks)

B) Give the names of the following compounds:

| | |
|---|---|
| $CuSO_4$ = | $Fe_2O_3$ = |
| $NaHCO_3$ = | $Li_3PO_4$ = |

(4 marks)

7. A) Draw dot and cross diagrams for the following compounds (show **all** the electron shells). Also state **what type of bonding** is present in each case.

i) carbon dioxide

Type of bonding: ______________________________

(3 marks)

ii) aluminium chloride

Type of bonding: ______________________________

(3 marks)

B) Draw dot and cross diagrams for the following compounds. (Show the **outer** electron shells only). Also state **what type of bonding** is present in each case.

i) magnesium oxide

Type of bonding: ______________________________

(3 marks)

ii) chlorine

Type of bonding: ______________________________

(3 marks)

C) Give 2 properties of ionic compounds.

i) ______________________________________________________________________

ii) ______________________________________________________________________

(2 marks)

D) Give 2 properties of covalent compounds.

i) ______________________________________________________________________

ii) ______________________________________________________________________

(2 marks)

———————————————————THE END———————————————————

# Appendix 12

# THE OBJECTIVES BEHIND EVERY TEST QUESTION IN THE END-OF-TOPIC TEST

**The Objectives behind every Test Question in the End-of-Topic Test**

| Question number | Outcome |
|---|---|
| 1A | To identify the point where ammonia gas and hydrogen chloride gas meet. |
| 1B | To name the compound formed in the tube when the two gases meet. |
| 1C | To name the process by which gases move from one place to another. |
| 2A | To explain why dust particles are seen to move on their own in sunlight. |
| 2B | To name what the process described in question 2A is called. |
| 3A | To draw an oxygen atom showing its full structure and label its different parts. |
| 3B | To explain why an oxygen atom is neutral. |
| 4A | To state how many electrons a particular atom has. |
| 4B | To identify the mass number of an element. |
| 4C | To identify the atomic number of an element. |
| 4D | To write the electronic configuration of a particular atom. |
| 4E | To state in which group of the periodic table a particular element belongs to. |
| 4F | To state whether a particular element is a metal or a non-metal. |
| 5A | To define the term isotope. |
| 5B | To calculate the R.A.M. of neon. |
| 6A | To write the formulae of the given compounds. |
| 6B | To write the names of the given formulae. |
| 7Ai | To draw a dot-cross diagram of a molecule of carbon dioxide showing all the electron shells and hence state its type of bonding. |
| 7Aii | To draw a dot-cross diagram of aluminium chloride showing all the electron shells and hence state the type of bonding present. |
| 7Bi | To draw a dot-cross diagram of magnesium oxide showing its outer electron shells only and hence state the type of bonding present. |

| | |
|---|---|
| 7Bii | To draw a dot-cross diagram of a molecule of chlorine showing its outer electron shells only and hence state its type of bonding. |
| 7C | To write two properties of ionic compounds. |
| 7D | To write two properties of covalent compounds. |