RELATIONSHIP BETWEEN THE ATTITUDE OF FIRST YEAR MEDICAL STUDENTS TOWARDS CHEMISTRY AND THEIR LEARNING OUTCOMES

by

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Abstract

Several factors that are known to influence attitudes of students towards learning have been documented. Some of these factors have been found to affect the achievement of students. In this study the relationship of the attitudinal disposition of students to their learning outcomes were assessed. Chemistry attitude questionnaire was used to assess the attitude of students and a pen and paper examination comprising of questions requiring declarative and procedural knowledge were used to assess learning outcomes of students. Correlation analysis and multiple linear regression analysis were used to assess relationship between attitude of students and their learning outcomes.

The results showed that attitude of students had a positive but moderate influence on their performance. The ANOVA results showed a statistical significant relationship between attitude of students and students' learning outcomes (F= 38.383, p=0.000).

Key concepts

Attitudes, learning outcomes, medical students, chemistry performance, declarative and procedural knowledge

Declaration

Student number: **554-966-3**

I declare that **RELATIONSHIP BETWEEN THE ATTITUDE OF FIRST YEAR MEDICAL STUDENTS TOWARDS CHEMISTRY AND THEIR LEARNING OUTCOMES** is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

SIGNATURE
(Mrs. M G Mogane)

DATE

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Table of Contents

Appendices

Figures

List of Tables

CHAPTER 1

Overview of the Study

1.1 Introduction

Scientific knowledge is regarded as a tool that advances medicine by being an essential factor in the development of clinical practice (Camps & Recuero, 2005). This study investigated the relationship of medical students' attitude towards chemistry and their learning outcomes. In most South African Higher Education Institutions chemistry is taught to first year medical students in order to equip them with the basic knowledge needed in chemistry related courses later in their studies. Medical students are therefore required to have a deeper understanding of chemistry concepts and principles and their application in various courses. In addition to this, students in medicine will be required to make independent decisions and judgments based on scientific evidence and reasoning when faced with challenging social and scientific issues later in their workplace (Facione as cited in Castle, 2005). This will only be possible if students have an advanced chemistry knowledge base. Students bring their own unique strengths, experiences, attitudes and understanding to the classroom. To be able to make sound judgments students will also require a positive attitude.

Almost all educational studies conducted during the last decade acknowledge the importance of positive attitudes in the learning process (Banya, 2005; Mostert, 2006; Osborne, Simon & Collins, 2003; Reiss, 2004; Shankar, Dubey, Palaion, Pranaya, Saha & Deshpande, 2005 and Trumper, 2006). The following studies emphasized that students' attitude positions affect their motivation which in turn affect their learning outcomes (Berg, 2005; Pina & Paco, 2005 and Sorge).

There are several factors documented in the literature that are known to influence the attitude of students towards science learning. In the study of Reiss (2004) attitude of students towards school science was affected by content, teaching method, and assessment method. According to Reiss (2004), students develop a negative attitude towards science in part as a result of the developing negative attitude to school science lessons. Ye, Skoog and Zhu (2000) revealed that gender also, has an influence on the attitude of students towards science, while Berg (2005) has shown that motivation has an influence on students' attitudes towards chemistry. Other factors include self efficacy, prior knowledge, family background and others.

The perceptions that students have about a subject has also been shown to influence how students feel about a subject and these perceptions have also been shown to have an effect on their learning outcomes (Faye, 1997; Kan & Akbas, 2006; and Yücel, 2007). A qualitative study by Ress, Sheard, and McPherson (2002) has indicated that medical students' negative attitude towards the learning of communication skills was due to the perception they have about the subject. Anvik, Gude, Grimstad, Baerheim, Fasmer, Hjortdahl, Holen, Risberg, and Vaglum (2007) also assessed medical students' attitude towards the learning of communication skills and found that the students` negative attitude towards the subject was due to the way it was taught. Mostert (2006) found out that the way statistic was taught and the content were responsible for the negative attitude of medical students toward biostatistics.

Teaching is one of the strategies used in the education system to equip students with knowledge. Chemistry at most medical schools is taught to first year medical students to equip them with the capacity to apply basic science knowledge in appropriate clinical situations. However the faculty of medicine at the Higher Education Institution in Gauteng in this study has been experiencing a high failure rate of students particularly in courses where the basic scientific knowledge is required. In a review of students' attitudes towards science, Osborne, Simon and Collins (2003) argued that the quality of teaching school science is the most significant factor influencing students' attitude towards science. Ebenerzer and Zoller (1993) have also revealed that teaching style is the major determinant of students' attitudes towards science and science teaching in high school. All these factors are also known to affect students' learning.

Laboratory work is often used to further explore knowledge gained in the classroom and it is therefore an integral part of science education. Science is driven by empirical evidence and if students are to perform satisfactorily in science they need to be involved in practical work. Practical work therefore also has an effect towards students' learning outcomes. However, Kaya (2005) argued that the type of laboratory experience a student receives depends on the pedagogy and instructional methodology used. According to Kaya (2005) if the students have an undesirable attitude towards the pedagogy or instructional method used during the learning process, their learning will be affected. From observation and by going through medical students' laboratory reports it became clear that students do not really think about what they are doing and why they have to do what they are doing. Students do not see the necessity of proving theories or challenging the scientific laws from textbooks, what is written in textbooks is the absolute truth according to them. This in turn resulted in their poor performance in laboratory assessment.

For most Higher Education Institutions students are awarded a pass by obtaining an aggregate score of 50% in their assessments. The aggregate score comprises of student’s performance in tests, tutorials, assignments and practical work. The use of an aggregate score is designed more to distinguish among students than to assess students’ understanding of fundamental concepts. A continuous method of assessment is employed to assess students in South African schools. Tan (1992) studied the effect of continuous assessment on medical students at a University in Malaya, (Malaysia). According to Tan’s findings, continuous assessment method had a negative influence over students’ learning. Continuous assessment method according to Tan (1992) resulted in students having surface knowledge. It was observed that frequent summative assessment made students to focus on passing the examination rather than in understanding the subject matter. According to Marton & Saljo as cited in Tan (1992), the type of knowledge acquired by students was due to the method of assessment which emphasized the acquisition of recall of facts which does not necessarily imply understanding.

Concerns that the education system cannot adequately prepare students for life and work in the 21st Century have prompted educationalists to explore new ways of designing curriculum. The current education system and assessment method in South African is outcome based. The outcome based education (OBE) is a system of education design that focuses on what students can do after the teaching process. The OBE approach is however a new system that was hastily passed on to educators by means of workshops where selected teachers who attended the workshops are expected to hold workshops for other teachers at their schools. This system is likely to compromise the delivery of relevant knowledge since these teachers could be lacking the philosophical background and practical know-how of the OBE approach. The old South African science curriculum emphasized science for the scientist. In the new curriculum the natural science curriculum requires that the teacher have expertise on four different themes such as physics, chemistry, biology and earth science. There is however, currently no South African university graduate with background in all these four areas (Rollnick, in The Star, 2007). In science this factor is compounded by the fact that physics and chemistry are taught as physical science and in most cases by a single teacher. It is therefore possible for most students entering the higher education system to develop an undesirable attitude towards either physics or chemistry due to lack of the basic knowledge required in these courses.

One of the task educators face when designing a course is deciding what they want their students to get out of their learning experience. During the learning process, students should progress from the lower level of cognition to the highest level of cognition. Learning outcomes are categorized in different ways in education research. The most popular way to characterize learning outcomes is the Bloom's cognitive Taxonomy. The taxonomy categorizes learning outcomes into six levels namely; knowledge, comprehension, application, analysis, synthesis, and evaluation (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956). Bloom's Cognitive Taxonomy is a domain used widely by psychologists, educationalists and researchers (Forehand, 2005). It is a multi-tiered model of classifying thinking according to cognitive levels. Since the taxonomy is hierarchical, using this model will enable educators to assess students' level of thought. In this way it is expected that students who are able to apply knowledge should have an understanding of the relevant concepts.

The original taxonomy has since been reviewed by cognitive psychologists, curriculum theorists, and instructional researchers and testing and assessment specialists and therefore accommodates a much broader audience. The advantage of the revised taxonomy is the inclusion of specific verbs and products linkage with each of the levels of the cognitive process dimension. The revised taxonomy can therefore be used for students from the primary level to the tertiary level. Also, the revised version shows the distinction between the different types of knowledge and cognitive processes (Anderson & Kathwohl, 2001). Dochy as cited in Hailikari, Nevgi, & Lindblom-Ylanne (2007), regard knowledge as comprising of the declarative and procedural knowledge. He defines declarative knowledge as accumulation of facts and concepts which comes to the surface through recognition or reproduction. Procedural knowledge on the other hand is knowledge of application and procedures which comes to the surface in assessment through production or application. In Anderson (1995) declarative knowledge is referred to as "knowing that" and procedural knowledge as "knowing how".

In Hailikari, Nevgi, & Lindblom-Ylanne (2007) it is recommended that an instrument used to measure learning outcomes objectively should be able to illustrate the level of conceptual understanding of the student. According to Dochy & McDowell in Hailikari, Nevgi, & Lindblom-Ylanne (2007) assessment of students using the revised taxonomy provide the possibility of exploring an individual's knowledge base on multiple dimensions. Klymkowsky, Garvin-Doxas, & Zeilik (2003) believe that this will enable educators to see the loopholes that must be closed in order for students to have conceptual understanding. The purpose of this study was to determine the relationship of attitude of students on their learning outcomes.

1.2 The Problem

Medical students are required to learn basic general and organic chemistry as a prerequisite for medical courses such as physiological chemistry, biochemistry, microbiology, pharmacology and chemical pathology. As a service course for medical students, chemistry aims at enhancing understanding and applicability of scientific concepts relevant in the medical field. For this purpose the teaching strategies and assessment methods used should be able to provide students with an understanding of basic principles required for the study of each course. Observation has shown that senior medical students at a Higher Education Institution in Gauteng (South Africa) in this study have difficulties in courses requiring basic knowledge of chemistry. This could be influenced by various factors such as attitude towards a subject or lack of relevant prior knowledge or lack of proper understanding.

At this particular Institution, chemistry is offered to medical students by the faculty of science and is therefore science based. In this way it is likely to offer discipline specific information which is transmitted to students in another field with the potential of not revealing the relationship and relevance between the facts and skills. This arrangement may lead to inadequate scientific preparation of health professionals that are unable to articulate the relevance of content knowledge to clinical situations. In an experiential study of Jelinek (1998) on perceptions and attitudes of middle school students it was discovered that when students recognize the connections between science and their personal lives they were inclined to display an improved attitude towards the learning of science. This was also supported by the study of Trumper (2006) who noticed that students are often interested in subjects related to their personal life and needs. In line with this, one can assume that when students are able to identify the connection between any particular subject with their own field of study they are likely to appreciate that subject, and pay particular attention to its study.

Chemistry in Medical Institutions is usually offered to a large group of students who will never become practicing chemists. The majority of these students are interested in the medical field courses such as medicine, dentistry, physiotherapy, nursing and others. The traditional teaching method is mostly used to teach these students. Studies have shown that lecturing is an ineffective teaching method that is teacher centered and based mostly on content knowledge which does not develop transferable skills to students. Besides these disadvantages, lecturing method is still in use because it is the most appropriate method for large group of students.

The usual learning style of laboratory instruction used at the Higher Education Institution in this study is the verification method whereby students are given practical manuals with the procedure to follow. Students are not given a chance of designing and drawing conclusions from their practical work but are forced to believe and memorize. According to Kaya (2005) the method of verification does not promote the necessary skills required for meaningful learning such as conceptual understanding, retention of content knowledge, scientific reasoning skills and better attitude towards science.

In the evaluation of the practical component, students are assessed by whether they were able to follow experimental procedures by obtaining desirable results. Students often strive to get the “correct” results. This approach has resulted in students copying results of other students or writing the report based on what they have learnt in class and not on what they have discovered in the laboratory. This assessment method will not indicate the true reflection of students’ knowledge. An assessment technique that will be able to indicate the conceptual development of the students is therefore required. In the study of Beck (1993) on students in introduction of physics, it was discovered that the negative attitudes of students was affected by how the role of laboratory work was defined. The discovery made was that students who make personal discovery of concepts usually have positive attitude towards laboratory work.

Observation made with first year medical students has shown that most first year medical students at the Education Institution in the study are often faced with difficulties in understanding basic chemistry concepts. Their knowledge of scientific concepts appear to be isolated facts void of context. Students are able to recall facts but are unable to see their applications in their field of study. Muwanga-Zake (2006) investigated the problems in South African Science Education in the rural Eastern Cape high school and revealed that the lack of understanding of science concepts and processes by most science teachers and the shortage of qualified teachers are some of the problems faced by the South African

Education system. Whereas the relationship of attitude and students' learning outcomes has been assessed elsewhere no such study has been conducted among first year medical students by looking at student´s performance in different knowledge categories at this Higher Education Institution in Gauteng.

There have been a number of previous studies to assess attitudes of students toward science and to identify factors that influence these attitudes but the relationship of attitude and students` naïve understanding of concepts, to my knowledge has not been done. This study will therefore assess the relationship between the attitude of first year medical students at a Higher Education Institution in Gauteng (South Africa) towards chemistry and their learning outcomes.

During teaching and learning we often overlook contributions of students' knowledge base as a learning outcome and the effects of attitude towards students` learning outcomes. This study will attempt to raise the level of awareness of the relationship between attitude of students and their performance in different knowledge components as well as the relationship of the overall performance scores of students and their scores in different knowledge components. Knowing the relationship between the knowledge base of students and their attitude towards chemistry will provide an indication of whether students will be able to transfer relevant information learned in one field to the other. Vygotsky's socio-historical culture theory argued that during the learning process learners are active participants and therefore the way they view the learning process could be an obstacle to their learning. It is therefore important to understand ways in which attitude may be a barrier to learning outcomes. Through this study it is also hoped that lecturers at the Higher Education Institution in this study will obtain some guidelines for effective design, development and assessment methods to facilitate teaching for transfer.

1.3 Aims and Objectives

The aim of the proposed study is: to investigate the relationship between attitude of first year medical students at a Higher Education Institution towards chemistry and their learning outcomes. The study has the following objectives:

1. To determine the attitude of first year medical students at a Higher Education Institution in Gauteng towards the teaching and learning of chemistry.

2. To assess learning outcomes of first year medical students in chemistry according to modified version of revised Bloom’s cognitive Taxonomy designed by Hailikari, Nevgi, & Lindblom-Ylanne (2007).

3. To determine whether there is a relationship between first year students’ learning outcomes and their attitudinal dispositions.

4. To determine the relationship between first year students’ knowledge base and overall performance in chemistry.

1.4 Research Questions

The study would like to address the following research questions:

1. What is the attitude of first year medical students at a Higher Education Institution in Gauteng towards the teaching and learning of chemistry?

2. How does first year students’ knowledge base rank according to the modified version of the revised Bloom’s cognitive taxonomy?

3. What is the relationship between first year students’ learning outcomes and attitude towards chemistry?

4. What is the relationship between first year students’ knowledge base and their overall performance in chemistry?

1.5 Significance of the Study

During teaching and learning we often overlook the contribution of the knowledge base of the students as a learning outcome and their attitude towards their learning experiences to their future learning. A full commitment to teaching and learning should include assessing and documenting what and how much students are learning and using this to improve the educational experiences being offered. The results of this study will go a long way to enable chemistry lecturers at the Higher Education Institution in this study to devise procedures aimed at improving the attitude of students in the health sciences towards chemistry and on advancing students` knowledge base of chemistry. Advanced knowledge and better attitudes of medical students towards science in general will benefit the medical profession more now than before because of the new policy on the recognition of the therapeutic effects of traditional medicines.

The results of this study could also be used by administrators to monitor the learning process of students which could help to predict their future progress. Program developers could also benefit from this study by using these results as a guide that will help in designing programs and activities that will advance students from one level of knowledge to the next and learning environments that will promote positive attitudes of students.

1.6 Organizations of the Study

This study is divided into five chapters.

Chapter one consists of the introduction, problem statement, purpose of the study, aims and objectives, significance of the study, and the organization of the study. The review of literature is discussed in chapter two. Chapter three contains the research methodology and procedures used in the study, design of the study, population of the study, data collecting procedures and data analysis methods. Chapter four presents the results and their discussion. Chapter five presents the summary, conclusion and recommendations.

CHAPTER 2

Literature Review

2.1 Introduction

The aim of this literature review was to establish the current status of information regarding the relationship of attitude of students towards science on their learning outcomes. This chapter covered factors influencing attitudes of students towards the learning of science and how attitudes are being classified and measured. The chapter also addressed students' learning outcomes and different ways of measuring learning outcomes, the relationship of students' attitudes and their learning outcomes and the relationship between their learning outcomes and performance.

2.2 Attitude

2.2.1 Definitions of Attitude

The concept attitude can be defined in different ways. Fishbein and Ajzen (1975) defined an attitude as a learned disposition to respond in a consistently favorable or unfavorable manner with respect to a given object. Thurstone as cited in Kan and Akbas (2006) defined attitude as the degree of sensation to an object or an individual while Güzel (2004) defined an attitude as the general evaluation of people about themselves, others, other objects, events or problems. Studies have shown that students with positive attitude towards their school work are likely to show commitment, interest, affection and a desire to learn more.

2.2.2 Types of Attitudes

Osgood *et al.* in Neerinck and Palmer (1979) established three major types of attitudes towards a given entity.

- Evaluative attitude

Evaluative attitude is the like-dislike attitude which is revealed in response to words such as "good", "bad' etc (Osgood *et al.* as cited in Neerinck & Palmer, 1979)

- Participative attitude

This is the activity attitude which is revealed by use of words such as "active", "static" etc (Osgood *et al.* as cited in Neerinck & Palmer, 1979).

- Potency attitude

This type of attitude is associated with the feeling of individuals about the utility of the object or concept. Potency attitude is revealed by use of words such as “useful”, “useless” etc (Osgood *et al*. in Neerinck and Palmer, 1979).

In most studies, attitudes are generally determined by examining their cognitive, affective and behavioral aspects (Berg, 2005; and Young, 1998). As a cognitive aspect, attitude can be expressed in terms of a set of knowledge and beliefs concerning an object as in thinking or reasoning. A statement such as “I think that this course is difficult” is an example of a cognitive response expressing an attitude towards a subject. Attitude can also be expressed as an affective response by relating the feelings or evaluation of a person with respect to an object. “I am interested in this particular course or I do not like practical work” are statements that will display how good or bad a person feels about an object. In this example a person is expressing his feelings towards a particular subject or an activity. An attitude can lastly be expressed in terms of a behavioral response such as absenteeism from classes or coming early to classes, in these examples a person is exhibiting some reactions towards an object.

In science education the cognitive domain is of primary concern. However, Kobella (1989) believes that the affective variable is as important as the cognitive variable in influencing learning outcomes. Trumper (2006) also argued that both affective and cognitive outcomes of science instruction are important during teaching and learning. Hence according to Trumper (2006), “without cognition there can be no affect and therefore no attitude.”

2.2.3 Factors influencing attitude of students towards learning

Studies have shown that the attitude of students towards learning are affected by factors such as method of teaching, performance, gender, motivation, relevance of subject to field of study, background and environmental factors (Banya, 2005; Berg, 2005; Choi & Cho 2002; Deratzou, 2006; Kaya, 2005; and Ye, Skoog & Zhu, 2000).

Different teaching methods have been used in an attempt to improve the attitudes of students toward studying science. Mostert (2006) reported that Bland, used method of argumentation based on students’ concept maps and this resulted in positive attitudes of medical students toward pharmacology. Kaya (2005) has also shown that the method of argumentation accompanied by concept mapping improved the attitudes of students towards chemistry laboratory practical work. The study has also shown that the method helped students to develop conceptual learning strategies. Choi and Cho (2002) used ethical issues to illustrate the fact that students' appreciation of science increases when they are able to see the relevance and practicality of the content in every day life.

Hullet, Williams, Twitty, and Turner (2004) used inquiry based learning method in teaching chemistry. The method of inquiry resulted in creating interest among students. Lin (1998) used history and philosophy of science and the resulting effect to attitude was favorable. Others used visual demonstration to support lectures (Deratzou, 2006), web-based project application (Morgil, Ural, & Temel, 2008) and motivation (Berg, 2005) to improve the attitudes of students toward chemistry. Zarotiadou & Tsaparlis in Coll and Taylor (2001) assert that: "every teaching method that involves students in an active way in the learning process will increase their positive attitudes towards science." However Ye, Skoog and Zhu (2000) studied the attitudes of Chinese secondary school students and discovered that the effect of teaching method on attitudes of those students was not significant. This was also supported by the study of Ebenezer & Zoller (1993) who found no change in the attitudes of high school students in spite of using the constructivist approach which is said to be an effective teaching method. Jarvis as cited in Banning (2005) views teaching as both an art and a science. As an art and a science teaching is therefore a continuous process that requires to be explored from a variety of perspective from time to time and as science teaching methods used should be refined from time to time.

Most studies on gender have revealed that males' ability and attitudes related to science are more positive than those of females Ye, Skoog, and Zhu (2000). Banya (2005) in his study on young female students' attitudes toward chemistry revealed that self confidence toward chemistry, influence of role models, and usefulness of chemistry have an influence on the attitudes of students toward studying chemistry. Çokadar, & Külçe, (2008) concluded that contradicting results makes it difficult to generalize the results of the study of attitude and gender.

With regard to chemistry as a science subject, (Demirciğlu & Norman, 1999) found no significant effect of gender on chemistry achievement and chemistry attitudes, while type of school (private or government) was shown to have a significant effect on chemistry achievement. Kan and Akbas (2006) also found no attitude difference according to gender towards chemistry in their study of affective factors that influence chemistry achievement. Ye, Wells, Talkmitt, and Ren (1998) found out that male students have slightly higher attitudes toward science with gender difference more pronounced in physics and chemistry than in biology.

2.2.4 Assessment of Attitude

From the definitions of attitude in 2.2.1, it appears that attitudes are not quantifiable. According to Kobella (1989) the most prominent quality of attitude is evaluating directionality- our favorable or unfavorable feeling towards something. Attitudes of students can be measured formally or informally. Formal assessments include self report surveys in the form of questionnaires which may consist of open-ended questions, multiple choice questions, or rating scales that allow students to indicate how strongly they agree or disagree with specific statements. Informal survey could be in the form of classroom observation where a teacher may ask how a student feels with regard to her teaching style and the student gives a verbal response to the question.

In most cases self administered assessment questionnaires have been used as an effective way of assessing students' attitudes. Questions included mostly in surveys involve the cognitive component as well as the affective component. Common questions used in the assessment of students' attitudes may be positive or negative. A statement such as: "chemistry is my favorite subject" is a positive statement while "I do not do well in chemistry is a negative statement. These statements can be answered by using rating scales which ranges from "I totally agree" to "I totally disagree". Likert type scales are often used to get quantitative information such as comparisons between different groups (e.g., girls versus boys) and they also permit factor analysis (Reiss, 2004) which can be used to check consistent reliability of the instrument. With regard to the validity of the Likert scale Dyer in Page-Bucci, 2003 stated that "attitudes scales do not need to be factually accurate - they simply need to reflect one possible perception of the truth." The responses of students to the statements will therefore indicate the feelings which each statement is triggering in them (Dyer as cited in Page-Bucci, 2003)

Open ended survey questions requiring students to fill in a response could also be used when one want to obtain general results. Open ended questions result in rich data which lead to complicated analysis and difficult interpretation of results (Reiss, 2004). When one wants to obtain specific answers, multiple choice questions could be used. Multiple choice questions can be answered by using a rating scale while in open ended questions the use of scales and ranking is not appropriate due to the diversity of the answers. Another method used in studies of Duckworth and Ormerod as cited in Osborne, Simon and Collins (2003) involved asking students to rank their liking of school subjects. The relative popularity of a subject is then taken as an indication of students' attitude toward a subject. Preference ranking is simple to use and the results are easy to present and interpret, however it is a relative scale.

2.3 Learning Outcomes

During the learning process, students should progress from the lower level of cognition to the highest level of cognition. In the education system, assessment is used as a strategy that helps in the evaluation of students' learning outcomes. Richards (2001) defined assessment as a way of measuring progress. Progress of learning can be illustrated when a student is able to use the acquired knowledge in appropriate situations

2.3.1 Factors Affecting the Achievement of Learning Outcomes

One of the first task educators face when designing a course is deciding what they want their students to get out of their learning experience. There are several factors that affect the learning outcomes of students. In majority of studies the learning experiences of the students have been shown to have a greater effect on student' learning outcomes (e.g. Kaya, 2005), other studies revealed that attitudes of students towards a subject have an effect on their learning outcomes.

2.3.1.1 Students' Learning Experiences

During the learning process students undergo many learning experiences in class or out of class. Some of these experiences take place formally in the form of lectures, presentations, laboratory work or assessment, while others are informal and can be in the form of tutorials, group discussions or peer tutoring.

Lecture is a formal teaching method that is widely used despite all the criticism against it (Jarvis as cited in Banning, 2005). Instruction by lecturing involves transmission of factual knowledge to a large group of students. This method is also referred to as rote learning because students passively acquire information from the lecturer with little interaction. According to Mundalamo (2007) learning by rote and accepting knowledge as received from the

teacher arises some of the attitudes that may be detrimental to students' success.
Banya (2005) regard chemistry as a human endeavour that relies on basic qualities like creativity, skepticism, reasoning and thinking skills which are rarely acquired using the traditional method of teaching and learning.

The choice of the most appropriate teaching method for a particular lesson will depend on many things among them are the developmental level of the students, their prior knowledge, attitude, the subject matter, content, the number of students in a class and availability of resources. The constructivist view of learning has an important consequence for the development of new teaching and learning approaches that focuses on student's understanding of science rather than the recall of facts and formulas (Duit & Confrey, 1996). In the constructivist' method the learner create their knowledge in search of meaning and understanding using prior knowledge. According to the constructivist theory knowledge without understanding is limited, too often forgotten, cannot readily be retrieved when needed, becomes quickly out of date and can only be applied in the limited context in which it was learned.

In the study of Muwanga-Zake (2008) on black South African students, language was revealed as another factor that affected students' learning outcomes. Muwanga-Zake, gave an example of scientific words such as energy, power and force which have different meaning in science but are expressed in one word in many African languages. In such cases Muwanga-Zake, says that majority of students will revert to memorizing the definitions of these terms without comprehending their meaning. The problem of using a second language in teaching was also observed on first year medical students by Gillet and Bayouni (1998) in the United Arab Emirates students.

Hofstein and Lunetta as cited in Hofstein and Lunetta (2003) reported that for over a century science educators have observed a rich benefit in learning that accrued from using laboratory activities. Tobin cited in Hofstein and Lunetta (2003) said that the effectiveness of teaching and learning in the science laboratory is possible if students are given the opportunities to manipulate equipment and materials in an environment suitable for them to construct their knowledge of phenomena and related scientific concepts. Such opportunities are however very rare in school science. The effect of chemistry demonstrations was shown in the paper presented by Erlis and Subramaniam (2004) to foster conceptual understanding especially among students with low linguistic intelligence and was therefore recommended to be used as a vehicle to promote thinking skills among students. Mokgokong (2006) has explained that the problem of chemistry practicals in South African schools in Gauteng is the lack of an instrument that will determine students' views of the benefit and problems of chemistry practicals. Kaya (2005) has suggested that the best laboratory style should promotes the specific learning outcomes such as conceptual understanding, retention of content knowledge, scientific reasoning skills, higher-order cognition, better attitudes toward science and laboratory manipulative skills. Expository or verification approaches in the laboratory on the other hand only allow the student to be able to follow directions at a predetermined outcome in order to illustrate an important reaction or verify a principle. Students who do not have a clear understanding of the underlying principles of the method of verification, unfortunately, will not advance to higher levels of being able to interpret the results or notice irregularities in their results.

Assessment is an integral part of learning that should be designed in such a way that will reinforce the promotion of transferrable skills. According to Shankar *et al*. (2003) it is important for medical students to develop among other things transferable skills which are not only important in undergraduate medical education but also for continued learning. Marton and Saljo cited in Tan 1992, claim that assessment that emphasizes the acquisition and recalling of facts induce surface approach and rote learning which does not necessarily imply understanding. Shankar *et al*. (2003) believe that understanding as a component of learning outcomes is displayed when students are able to relate an idea with a familiar concept or are able to assimilate information in a manner that will make it efficient. Progression through the stages of being able to use acquired knowledge should be revealed in the type of questions asked (Hailikari, Nevgi, & Lindblom-Ylanne 2007). The Bloom's cognitive taxonomy is the classification of knowledge in a hierarchical way into levels. The taxonomy is such that the higher knowledge level subsumes the lower knowledge level.

Using this taxonomy in the evaluation of students could reveal the knowledge base of students.

2.3.1.2 Students' Attitudes

There are many studies in the education system that have associated poor performance of students with their negative attitudes. Russell and Hollander as cited in Rogers and Ford (1997) assert that "the likelihood of students putting his knowledge to use is influenced by his attitude for or against the subject. Simpson and Oliver (1990) stated that a positive commitment to science which influences lifelong interest and learning of science is mostly due to positive attitude to science.

2.3.2 Classification of Learning Outcomes

2.3.2.1 Bloom's Cognitive Taxonomy

The well known taxonomy of educational objectives was formulated by Benjamin Bloom and his associates in the 1950's. The taxonomy focuses on three taxonomies, cognitive, affective and psychomotor. The cognitive taxonomy consists of six kinds of learning that are arranged in a hierarchical order. This taxonomy is hence widely used to assess the progression of learning outcomes from novice level to expert level.

Bloom's cognitive taxonomy has been the most universally applied classification of higher order thinking (Aksela, 2003). The Taxonomy is a knowledge base domain increasing in difficulty from knowledge to evaluation. Each level in the taxonomy encompassed those below it, the ability to analyze information will only occur after the ability to apply and understand acquired knowledge had been accomplished. Students who are able to apply acquired knowledge are therefore assumed to have an understanding of the concept.

In the educational system the taxonomy is widely used to organize objectives according to levels of expertise. Bloom's Cognitive Taxonomy has since been condensed, expanded and reinterpreted in a variety of ways (Forehand, 2005).

2.3.2.2 Anderson' Revised Cognitive Taxonomy

Bloom's taxonomy was revisited by Anderson and his associates during the 1990's in order to examine its future relevance. In Anderson's Revised Cognitive Taxonomy there are also six cognitive processes; from knowing, understanding, applying, analyzing, evaluating to creating. The changes made on the original Bloom's Taxonomy are in three broad categories: terminology, structure and emphasis. In Table 2.1 the difference between the original taxonomy and the revised taxonomy are illustrated.

- Terminology changes

Each cognitive level in the original taxonomy is associated with certain learning outcomes expressed as verbs such as name, define, interpret, calculate, explain or critique. In the original taxonomy categories for these learning outcomes were changed from nouns to verbs. The lowest level of the original taxonomy was changed from knowledge to become remembering, while comprehension and create were named understanding and creating. Anderson's Revised Cognitive Taxonomy has now placed create as the last and highest level of learning their argument is that evaluation is a step which precedes any generative process such as creating.

- Structural changes

The original taxonomy was one dimensional while the revised taxonomy is now two dimensional. The knowledge dimension is the first dimension which describes the knowledge to be learned while the second dimension is the cognitive dimension which identifies the process used to learn.

Table 2.1 The Difference between Bloom's Original Taxonomy and Anderson's Revised Taxonomy and their Levels

Thinking Skills Levels	Levels of Bloom's Original Cognitive Taxonomy	Levels of Anderson's Revised Cognitive Taxonomy
Lower order thinking	Knowledge	Remembering
Lower order thinking	Comprehension	Understanding
Higher order thinking	Application	Appling
Higher order thinking	Analysis	Analyzing
Higher order thinking	Synthesis	Evaluation
Higher order thinking	Evaluation	Creating

- Changes in emphasis

Compared with the original taxonomy, the revised taxonomy has taken factors such as students' development and learning and teachers' planning, teaching and assessing into consideration.

Emphasis of the revised taxonomy is on student–oriented, learning based, explicit and assessable statements intended cognitive outcomes. The primary goal of the revision was to make the taxonomy to be applicable across all educational levels from elementary level to tertiary level and is therefore designed for a much broader audience.

2.3.2.3 Hailikari, Nevgi, & Lindblom-Ylanne (2007) Modified Taxonomy of prior knowledge

Hailikari, Nevgi, & Lindblom-Ylanne (2007) constructed a prior knowledge assessment model instrument based on the model of prior knowledge inferred from Bloom's revised taxonomy, Dochy's studies on the educational-psychological dimension of prior knowledge and Bigg's theory of structurally developing understanding. While the revised Bloom's taxonomy presents the kind of knowledge to be learned and the cognitive process, the developed model (Figure 1) presents three layers: the kind of knowledge to be learned, their indicators as well as their classification. Hailikari, Nevgi, & Lindblom-Ylanne (2007) believe that the model will be able to distinguish between students who have achieved the highest level of procedural knowledge from those who did not.

	Declarative knowledge		Procedural knowledge	
Knowledge Components	Knowledge of Facts	Knowledge of Meaning	Integration of Knowledge	Application of Knowledge
Indicators	Recognizing, recalling, remembering	Defining, reproducing, understanding the meaning of concepts	Understanding concepts and their inter-relations, classifying, and comparing	Problem solving, application of knowledge, producing, and implementing

Applying

Cognitive Process

Understanding

Knowing

Figure 1 Hailikari's Modified Revised Bloom's Taxonomy

In this model, declarative knowledge is divided into knowledge of facts and meaning which are assessed using tasks based on student's ability to recognize, recall and reproduce prior knowledge. The procedural knowledge on the other hand is divided into integration and application of knowledge. Understanding is the lowest level in this component and will be characterized by the ability of a student to see the interrelations between concepts and how different phenomena are linked to each other. The highest level will be characterized by student's ability to apply knowledge and to perform problem solving tasks (Hailikari, Nevgi, & Lindblom-Ylanne 2007).

2.3.3 Knowledge Categories

All four knowledge categories listed in the Hailikari, Nevgi, & Lindblom-Ylanne (2007) modified revised Bloom's Taxonomy are necessary in the learning process.

Factual knowledge is knowledge of facts and knowledge of meaning which is largely based on memorization of facts and procedures. In chemistry this knowledge base is probed with simple recognition or reproduction tasks such as listing the elements in the periodic table or naming of compounds. In this category formal knowledge is required before interrelationships of concepts (Anderson & Krathwohl as cited in Aksela, 2005).

Conceptual knowledge is a more complex, organized form of knowledge component that requires an ability to understand meaning of concepts and how different facts are related to each other. There are three subtypes in this category according to Anderson and Krathwohl as cited in Aksela, 2005: (a) knowledge of classification and categories, (b) knowledge of principles and generalizations and (c) knowledge of theories, models and structures. The knowledge base in this category is probed with questions requiring students to interpret, infer or summarize a given concept.

Procedural knowledge is the knowledge of "how to do something" and therefore includes knowledge of skills and algorithms, techniques and methods procedures, as well as knowledge of criteria used to determine and/or justify when to do what within specific domains and disciplines. Tynjälä, (1999) define this knowledge category as expertise practical knowledge which manifests itself as skills of "knowing how". Questions requiring students to carry out, judge or critique a procedure, technique or concept are used to probe this knowledge base (Anderson and Krathwohl as cited in Aksela, 2005).

Meta – cognitive is defined as knowledge about cognition in general as well as knowledge of one's own cognition. It is therefore not subject specific (Anderson & Krathwohl as cited in Aksela, 2005).

2.3.4 Cognitive Process Categories and their Indicators

Remember is the first step of cognitive growth in the revised taxonomy. By remembering one has to retrieve relevant knowledge from the long term memory. "What is the symbol of tin?" is an example of a chemistry question requiring a student to recall the symbol used for the name of an element tin. Remember is a process category used to promote retention of presented material. At this level students are required to exhibit skills to recall, identify, define, select, list, state or match information (Anderson & Krathwohl as cited in Aksela, 2005).

Understand is defined as constructing meaning from instructional information in the form of oral, written or graphic communication. "interpret the following experimental data" is a question requiring students to explain the relationship of concepts to empirical evidence. In order for the student to use this particular skill and not recognizing or recalling skills, information given in the task must be new. The key words that can be used to characterize this skill level are: derive, explain, illustrate, interpret, rephrase or summarize (Anderson & Krathwohl as cited in Aksela, 2005).

Apply is the first higher order thinking skill requiring a student to complete or use a procedure from one situation to another. Apply, consist of two cognitive processes: executing - when a task is familiar – and implementing- when a task is unfamiliar. A question such as "from your everyday experiences, use two examples to show the effect of temperature on the rate of reaction." The keywords that distinguish this skill level are: apply, choose, show, use, classify or employ (Anderson & Krathwohl as cited in Aksela, 2005).

Analyze is the second higher order thinking skill which is achieved as a result of drawing reasonable conclusion based on empirical evidence. A question such as "what can you deduce from the given results?" is an example of a question requiring a student to analyze the results and come up with their view based on domain specific knowledge. The keywords for this level include: analyze, deduce, determine, detect or infer (Anderson & Krathwohl as cited in Aksela, 2005).

Evaluate is the third higher order thinking skill which means making judgments based on criteria and/or standards. A question such as “justify the following results” is an example of this type of knowledge. The verbs associated with this level include to: argue, judge, assess, justify, decide or appraise. (Anderson & Krathwohl in Aksela, 2005). A question such as “what is wrong with this name 1-propanone?” is an example of a question in this category.

Create is the last higher order skill which require one to put concepts together to form a novel, coherent functional whole or reorganizing parts into a new pattern. This level uses previous knowledge to develop a solution, product or proposal for oneself. The learning outcomes associated with this knowledge include to: design, create, predict, produce, propose or invent (Anderson & Krathwohl as cited in Aksela, 2005).

Achieving the learning outcomes in the learning process links the student activities to the intended learning outcomes. In this way feedback from the students is obtained to determine the success of the learning process.

Table 2.2 The knowledge dimensions and the cognitive process dimensions

The Knowledge Dimension	The Cognitive Process Dimension					
	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	Remember					
Conceptual Knowledge	Remember	Understand				
Procedural Knowledge	Remember	Understand	Apply	Analyze		
Meta-cognitive Knowledge	Remember	Understand	Apply	Analyze	Evaluate	Create

2.3.5 Knowledge and understanding

Knowledge production in science is an ongoing process that usually happens gradually occasionally when new knowledge replaces the dominant view. In the education system, teaching and learning are used to acquire knowledge. According to constructivism during learning students should construct their own knowledge by testing their own ideas and approaches which are based on their previous knowledge and experiences applying this to new situations and integrating the new knowledge to pre-existing intellectual constructs. From this philosophy one can conclude that knowledge is valuable in learning. Having knowledge is often confused with understanding.

Kvanvig, 2003 as cited in Pritchard, (unpublished) argues that understanding is an epistemic standing that is closely related to knowledge, but it is understanding which is distinctively valuable in a learning experience. Kvanvig distinguishes knowledge from understanding by reasoning that: “understanding, unlike knowledge admits to degrees” that is; one can have an understanding without knowing, while with knowledge if one does not know he does not know. Kvanvig also beliefs that understanding is immune to epistemic luck while with knowledge one can know through guessing. According to Bloom, Engelhart, Furst, Hill and Krathwohl (1956) a solid understanding of principles enables one to comprehend scientific terms and to confidently apply knowledge gained in one setting to another setting and to make informed judgment about new discoveries.

2.3.6 Assessment of Learning Outcomes

Assessment is a very important aspect of teaching and learning which is related to the achievement of the learning outcomes (Holbrook, 2005). In the education system, assessment is used as a strategy that helps in the evaluation of students’ learning process (Richards, 2001). Different assessments are available for collecting evidence that learning has taken place. Observation–based method, test–based method, task-based or performance-based as well as self, peer and group assessment and test- based assessment are examples. According to Van Der Horst and Mc Donald as cited in Richards 2001, knowledge, behavior, performance values or attitudes can be measured by assessment. Hailikari, Nevgi, & Lindblom-Ylanne (2007) recommended that different types of assessment methods should be assessed for different types of knowledge.

There are several studies quoted Scalise, Claesgens, Krystyniak, Mebane, Wilson, and Stacy (2003) which revealed that much of the chemistry content is currently being taught and assessed in terms of facts and algorithm and procedural knowledge with little emphasis on conceptual understanding. Shankar *et al*. (2005) recommended that in learning, students should develop transferable skills which are important, not only in undergraduate medical education but also for continued learning throughout their medical career. For students to have transferable skills it will require that they should progress from the novice level of understanding to the graduate and expert levels of being innovative.

There is, currently, unfortunately no general well designed assessment instrument available for identifying gaps in students' understanding. Most questions in Advanced Placement Exams like Biology Advanced Placement Exam privileges the retention of knowledge with little emphasis or no conceptual understanding (Klymkowsky, Garvin-Doxas and Zeilik, 2003). Standardized tests that exist are designed to distinguish performance of one student from another student than to assess student's understanding of concepts (Klymkowsky, Garvin-Doxas and Zeilik, 2003 and Scalise *et al.*, 2003).

Educational studies of prior knowledge in learning and performance emphasize the importance of prior understanding in the construction of new understanding (Hailikari, Nevgi, & Lindblom-Ylanne 2007). Literature in the education system distinguished declarative knowledge from conceptual knowledge and their components. Using this distinction it is assumed that different types of knowledge will be measured using different types of tasks. Hailikari, Nevgi, & Lindblom-Ylanne (2007) used different assessment measures to assess different types of knowledge and a model that distinguishes between these types of knowledge. In their study they discovered that not all types of prior knowledge influences student achievement.

Critical thinking skills are on the higher level of hierarchy in the cognitive taxonomy of education and should therefore be assessed using appropriate questions. Castle (2006) recommends that in assessing these skills, questions should move from asking students to describe and explain to asking them to discuss and evaluate. The results of the study of Hailikari, Nevgi, & Lindblom-Ylanne (2007) revealed that students who perform well in the procedural knowledge tasks which are on a relatively higher level are likely to get better final grades. The results further revealed that: for students taking an obligatory course, performance in application of knowledge tasks was a stronger predictor of final grade than performance in integration of knowledge tasks. For students who took the course voluntarily performance in integration of knowledge tasks was the only variable predicting final grades. The implication of these results, according to Hailikari, Nevgi, & Lindblom-Ylanne (2007), is that students who are able to succeed in tasks in a lower cognitive level will also possess these skills at the beginning of a new course. Students' performance is usually measured by an achievement test using different formats. Six types of assessment methods that have been identified from previous studies are: multiple choice tests, open questions, association test, recognition test, free recall and self assessment.

Table 2.3 Adapted from Anderson L. W. & Krathwohl D. R. (eds). *A Taxonomy for Learning, Teaching and Assessing* (based on Bloom's Taxonomy), *2001*.

Taxonomy	Definition	Related Learning Verbs	What the Student Does
Remember	Recall specific bits of information	Tell, list, name, repeat, identify, state, select, match, know, locate, report, observe, choose, who, what, where, when, cite, define, indicate, label, memorize, outline, relate,	Responds absorbs remembers recognizes
Understand	Construct meaning from information	Explain, restate, find, describe, clarify, illustrate, diagram, outline, summarize, interpret, paraphrase, transform, compare similarities and differences, derive main idea, arrange, convert, give examples	Explains translates demonstrates interprets summarizes
Apply	Use methods, concepts, principles, and theories in new situations	Apply, employ, solve, use, demonstrate, illustrate, show, report, draw, collect, classify, change, compute, construct, interpret, investigate, manipulate, modify, organize, predict, prepare and produce,	Solves novel problems demonstrates uses knowledge constructs
Analyze	Identify how parts relate to one another or to a larger structure/purpose	Analyze, dissect, detect, test,discriminate, distinguish, examine, focus, find coherence, survey, compare, contrast, solve,classify, outline, separate, structure, categorize, determine evidence conclusions, appraise	Discusses uncovers lists dissects compares and contrasts
Evaluate	Judge the value of something based on criteria, processes, or standards	Coordinate, judge, select/choose, decide, debate, evaluate, justify, verify, monitor, measure, what worked, what could have been different, what is your opinion, test, assess, compare, explain	Judges disputes forms opinions
Create	Generate a coherent functional whole; recognize new patterns	Create, design, construct, invent, imagine, present, deduce, induce, bring together, predict, organize, plan, modify, improve, suppose, produce, set up, what if, propose, arrange	Generates hypothesize design produce construct argues

Self assessment and free recall methods have been criticized by, Dochy *et al.* in Hailikari, Nevgi, & Lindblom-Ylanne (2007) as methods of assessing knowledge because of their influence of the subject' verbal abilities while the other four assessment methods are regarded as being fairly valid and objective ways of assessing knowledge. Nasser (2001) also stated literature arguments of the viability of multiple choice and short open ended questions when assessing higher order knowledge skills. However, he quoted some authors who believe that when adequately constructed these test formats can be able to assess students knowledge, their understanding and their ability to use and apply knowledge gained. A statement made by Palmer and Devitt (2007) is that: "A well constructed multiple choice question will be unambiguous, clearly set to a defined standard and easy to mark but more often than not tests little more than recall of facts." Open question method might test higher order cognitive skills but are often time consuming to mark and risk considerable variation in standards of marking (Palmer & Devitt, 2007).

In Palmer and Devitt (2007) modified essay questions for summative assessment of undergraduate medical students were employed and the discovery was that modified essay questions were not adequate in assessing higher cognitive skills whereas multiple choice questions in most cases were able to test higher order thinking skills. In assessment of a particular knowledge base Anderson and Krathwohl (2001) recommend the use of various verbs associated with the type of assessment as a guide, Table 2.3. Some of these verbs are specific to a particular category while the use of other verbs will depend on the structure of the question.

2.4 Conclusion

This chapter presented a theoretical framework aimed at connecting the current knowledge of attitudes of students towards science/ chemistry and their learning outcomes and the effects of students' attitudes on their learning outcomes. Research findings indicated that attitudes of students are influenced by many factors which could have an influence on their learning outcomes. Other studies revealed that the way students acquire knowledge will determine the type of knowledge they have which will have an influence on both their current and future learning. Most studies have revealed that lack of understanding of fundamental chemistry concepts can lead to poor performance in subsequent courses with the result of high failure rate often accompanied by negative attitudes. In this study the aim was to investigate the effects of attitude of medical students at a Higher Education Institution in Gauteng (South Africa) towards their learning outcomes using the model of Hailikari, Nevgi, & Lindblom-Ylanne (2007). In the next chapter the research methods followed in collecting, analyzing and presenting the findings are presented.

CHAPTER 3

Research Methods

3.1 Introduction

Information about the attitudes and learning outcomes of students toward a particular entity has been gathered using different strategies in many learning institutions. This chapter will explain the development of instruments used to assess the attitudes and learning outcomes of University of Limpopo medical students at Medunsa campus. The research design, sample administration of the instrument and data collection methods will also be outlined. Reliability and validity as well as the statistical analysis methods to be used will also form part of this chapter.

3.2 Design of the study

The aim of this study was to assess the attitudes and learning outcomes of first year medical students towards chemistry and the relationship between attitudes of students towards chemistry and their learning outcomes in chemistry. In the study the type of knowledge that the students have acquired during the year will be correlated with the attitudes that have developed along the teaching and learning process. The design of this research is therefore retrospective ex post facto-correlational.

3.3 Study Sample

The sample consisted of 103 medical students in a chemistry I class at a Higher Education Institution in Gauteng (South Africa). A convenient sampling method was used in this study. This methodological decision was taken due to the accessibility of the participants. There were 48 (46.6%) females and 55 (53.4%) males in the sample.

3.4 Data Collection Methods

3.4.1 Instruments

A chemistry attitude questionnaire was used as an instrument to collect both the qualitative and quantitative data for the assessment of attitudes of students towards chemistry. Qualitative research technique is usually employed in order to exploit the richness of the possible research findings while quantitative technique is used to provide statistical descriptions, relationships, and explanations (McMillan & Schumacher, 2001). The addition of qualitative data was therefore aimed at improving the ability to interpret the quantitative findings particularly since there was no concurrent control group of students with which to compare. Qualitative and quantitative data were collected concurrently and were therefore used to validate quantitative data. The open-ended questions were analyzed by noting the most frequent statements from the students' responses. Ratings on the chemistry attitude questionnaire were used for the quantitative analysis. Ratings of individual students were summed to produce total attitude score of individual students. An examination paper developed by the researcher and the students' lecturer was used to obtain the scores of students in both the declarative knowledge questions and procedural knowledge questions. The researcher was personally involved in the data collection process.

3.4.1.1 Development of the instrument to measure attitudes of medical students.

A Chemistry Attitude Questionnaire (CAQ) was developed by the researcher by adopting some statements from various attitude questionnaires such as those in Choi & Cho (2002) and Shankar *et al.* (2005). This was done in order to make the questionnaire to be suitable for the type of students in this study. The questionnaire consisted of three sections, the first section required demographic background of students such as gender and race. Information about the race of students will not be used since most students did not specify their race. This should be understandable considering the history of our country. A statement asking students about their attitude toward chemistry at high school was also included in the first section. Students responded to this question by indicating whether they liked chemistry, were neutral towards it or hated it in high school.

The second part of the questionnaire consisted of forty, five-point Likert type scale statements. The statements in the CAQ were based on the cognitive, as well as the affective components of attitude in varying proportions. Some statements required students' opinions regarding the teaching and learning of chemistry. Statements in the questionnaire were randomly ordered. In responding to the statements students were asked to read each statement carefully and mark the degree to which they agree or disagree using the following keys: **1-strongly disagree, 2-disagree, 3-neutral, 4-agree and 5-strongly agree**. Both positive and negative statements were included in the questionnaire. The use of positive and negative statements was to try to encourage participants to read the statements carefully rather than simply ticking the same response for each statement. The total score was calculated for each individual respondent by summing up their ratings. The values of the responses for negative statements were reversed in order to maintain unified direction on the scale. Positive attitude of students is reflected by high scores and negative attitude by low scores. The maximum score that could be attained was 200 and the minimum score was 40.

To allow for the spread of opinion it was decided to devise four categories that summarized the degree of first year students' attitudes towards chemistry. Students with scores of over 180 were deemed to have the most positive attitudes (at least half of the statements were scored 5 and the other half 4). Students with scores from 140 to 180 were deemed to have a moderate positive attitude (at least half of the statements were scored 4 and the other half 3). Students with scores from 100 to 140 were deemed to have a moderate negative attitude (at least half of the statements were scored 3 and the other half 2). Students with scores from 60 to 100 were deemed to have most negative attitude (at least half of the statements were scored 2 and the other half 1).

The third part of the questionnaire consisted of open ended questions. The open ended questions were adapted from Shankar *et al*. (2005). In this section, the students were asked to provide their opinions about the most important strengths and weaknesses of the department with regard to teaching and assessment. Students were also asked to provide two suggestions on how the teaching and learning of chemistry could be improved. Statements provided by students were analyzed by noting the most frequently made suggestions in order to obtain an idea about general feelings of the students regarding teaching, learning and assessment at their institution. These results were compared with the results from the second part of the questionnaire.

3.4.1.2 Development of the instrument to measure students' learning outcomes

The learning outcomes of students in chemistry were assessed through a paper based written examination on different topics from their syllabus selected by their lecturer. Previous chemistry test papers as well as the learning objectives outlined in their chemistry manual and course guideline together with their prescribed book were used in preparing the examination and the marking guide. The researcher provided two chemistry lecturers, and another lecturer from physiological chemistry with the framework of the instrument. A series of questions distinguishing between declarative and procedural knowledge and their subcomponents covering the full content of their course were selected by these lecturers. Questions were based on students' knowledge to recall, define, apply and integrate information. Verbs such as those in Table 2.3 were used as guidelines when categorizing questions in different components. Keeves cited in Hailikari, Nevgi, & Lindblom-Ylanne (2007) reported that the distinction of questions using verbs such as those in Table 2.3 is often used in the education practice and it is widely accepted. An initial draft of the examination paper was constructed and given for validation to two experienced chemistry lecturers and a lecturer in science education. Their feedback was used to fine tune the format and structure of the questions. The researcher, students' lecturer and a senior lecturer in the department of physiology who was a lecturer in biochemistry finalized the examination paper as well as the marking guide. They were also involved in categorizing the questions according to their knowledge components. The examination was marked by the students' lecturer and remarked by the researcher. In case of different marking on any question the senior lecturer involved in the selection and writing of the marking guide of questions was called in to give his opinion. If two from the three agree on a particular mark then that mark was taken.

The instrument used to assess students learning outcomes involved content mastery at different levels from knowledge and comprehension to higher cognitive levels of application and integration. In the model it is assumed that operating on the higher level of knowledge subsumes the lower levels of knowledge. Therefore students who are able to integrate concepts are assumed to have an understanding of the concepts. The total mark for the examination was 75 of which 37 marks were on knowledge of facts and definitions (declarative knowledge), 38 marks were on integration and application of knowledge (procedural knowledge). Within each knowledge category a scale to describe students understanding was adapted from Hailikari, Nevgi, & Lindblom-Ylanne (2007), see Figure 1 in chapter 1. According to Hailikari , Nevgi, & Lindblom-Ylanne (2007) the four sublevels within the two levels are constructed in a continuum that will show the progression of students' learning from the lowest level of being able to recall and define to being able to integrate and apply stored knowledge.

In knowledge of facts category, students were tested on their ability to articulate their ideas about chemistry concepts using prior experiences, observations, logical reasoning and prior knowledge to providing evidence for their ideas. Knowledge of meaning focused on students' ability to explore the language of chemistry and specific symbols used in chemistry. Integration of knowledge focused on the understanding of concepts and how different concepts relate to each other. Application of knowledge focused on problem solving where relevant knowledge is used in calculating required information. Table 3.1 illustrates some examples on how and why questions from the paper were categorized.

Table 3.1 Categories of sample questions

Sample Question	Knowledge Category	Explanation
Define the following terms: Atomic number, element, compound and radius.	Knowledge of Facts	The question requires the student to recall stored information concerning the meaning of the given terms
What do subscript numbers 2 and 3 in the formula $Ca_3(PO_4)_2$ represent	Knowledge of Meaning	The question requires the student to know the meaning of the numbers in formulas of compounds
Write down the balanced equation for the reaction that takes place in the stomach after a person takes a dose of $Mg(OH)_2$	Knowledge of Integration	The question requires the student to analyze the question then move from recalling, understanding, applying rules required in writing and balancing of equations
Calculate the concentration of hydrochloric acid in the persons' stomach if the pH is 1.	Knowledge of Application	A student will move from recalling the relationship between concentration and pH, and the relevant formula to be used, interpret the formula and calculate

Responses to the questions for each knowledge category were scored according to the operationalization method in Table 3.2 while the analysis of student's responses were based on the marking guide in the question paper prepared by the author and two other lecturers.

Table 3.2 The operationalization of different knowledge components (modified version from Scalise *et al.* 2003)

Component	Operationalization	Scale
Knowledge of facts	Free recall, enumerating domain specific concepts	0= < 0.5 of the allocated mark 0.5 =0.5 of the allocated mark 1=>0.5 of the allocated mark
Knowledge of meaning	Open questions: giving definitions to recalled concepts	0= < 0.5 of the allocated mark 0.5 =0.5 of the allocated mark 1=>0.5 of the allocated mark
Knowledge of integration	Understanding concepts and their inter-relations	0= < 0.5 of the allocated mark 0.5 =0.5 of the allocated mark 1=>0.5 of the allocated mark
Knowledge of application	Problem solving tasks and applying knowledge to other contexts	0= < 0.5 of the allocated mark 0.5 =0.5 of the allocated mark 1=>0.5 of the allocated mark
Overall score		

Answers to the questions measuring each knowledge category were coded as 0 for any answer below half of the allocated mark on the question paper, 0.5 for half the mark allocated on the question paper and 1 for any mark above half the allocated mark (example, if the total mark allocated to a particular question is 4, any mark less than 2 is coded as 0, a mark of 2 as 0.5 and any mark above 2 as 1). Students who obtained 0 in any question will be classified as being on the declarative knowledge level, those that obtained 0.5 as being on the procedural knowledge level and those who obtained 1 as being above the procedural knowledge level. The performance of each student will be illustrated as the percentage of the overall score of correct answers obtained as assigned by the examiners in the question paper. The operationalization of different components of knowledge is represented in Table 3.2.

3.4.1.3 Instrument Reliability and Validity

Reliability and validity are important aspects that a researcher should address if the results are to be of any significance. Reliability is mostly defined as the ability of an instrument to provide similar results every time it is administered to the same sample at different times. Research literature lists four forms of reliability; Split-half, Coefficient of Consistency, Test-retest and Alternate-form. In the present study, internal consistency of the scores was established by computing Cronbach alpha coefficients. For the 40 statements of the first year student's questionnaire Cronbach alpha coefficient was 0.78 while for the learning outcomes instrument Cronbach alpha coefficient was 0.62 for 25 items.

Lin, in Deratzou, (2006) suggests three types of validity; construct validity, internal validity and external validity. It is stated in Deratzou (2006) that multiple sources of evidence are used to ensure construct validity, while triangulation of data, member checking and clarifying investigator bias are employed for internal validity, while external validity implies the generalizability of the data to other population which is usually difficult in qualitative studies (Bogdan & Biklen as cited in Deratzou (2006).

3.4.1.4 Administration of the instruments

Questionnaires to assess attitudes of students towards chemistry were administered to all students in September 2008 during students' tutorial session. The rights of the students and purpose of the study were explained to all students by the researcher. Students were also informed that their responses to the questionnaire will only be used for this study. Questionnaire papers were coded in order to match the examination score of individual students to their respective attitude score.

A pen and paper examination covering the whole scope of chemistry I syllabus for medical students was used to assess the learning outcomes of the students. Permission was obtained from examination department and department of chemistry to use the results for the study. The examination was chosen since this will provide a wide scope of questions and it will also not be necessary for the researcher to urge students to prepare. The examination was compulsory and it was written in October 2008. The total number of students who wrote the examination was 121. The duration of the examination paper was two hours. Questions in the examination paper were grouped into those requiring declarative knowledge and those requiring procedural knowledge. Performance of students in the examination was taken as the sum of performance scores of individual student in the declarative knowledge questions and procedural knowledge questions as assigned in the question paper. Scores of students in the learning outcomes assessment were expressed in percentage. All students who submitted a completed questionnaire and wrote the chemistry examination were selected for the study. From a sample of 121, 103 (85.1%) students successfully completed the attitude questionnaire and their responses were used in the analysis.

3.5 Data Analysis

The aim of the study was to assess the relationship between students' attitudes towards chemistry and their learning outcomes. For the purpose of this study, descriptive analysis was employed to first assess the attitudinal disposition of students towards chemistry and for their learning outcomes. The Pearson correlation statistic was employed to obtain the relationship of attitudes of students and their learning outcomes as well as the relationship of their overall score in the examination and their performance in different knowledge components. Simple linear regression analysis was employed to obtain which variable predicted the learning outcomes of students. Results were displayed in tables and graphs.

3.6 Conclusion

This chapter presented the research design, methods followed in the present study the development and administration of the instruments to be used in answering the research questions. The sample was defined and the statistical procedure to be followed was highlighted. In the next chapter results from this study will be illustrated.

CHAPTER 4

Results

4.1 Framework for the Analysis

This chapter presents the findings of the data collected using qualitative and quantitative research methods. The findings emanating from the study were drawn from scores from the questionnaire and a pen and paper chemistry examination of the first year medical students. The questionnaire presented the respondents' attitude scores of the first year medical students while the examination presented the performance of students in different knowledge components.

4.2 Presentation of the Results

4.2.1 Descriptive Results of Students' Attitudes Towards Chemistry

The total number of students who completed the questionnaire was 103 this represented 85.1% of the total cohort. Of these students, 46.6% were female (n=48) and 53.4% male (n=55). Over 38.6% students responded that they liked chemistry at school while 44.3% were neutral and 17.1% did not like chemistry. The initial analysis involved the descriptive results of the attitudes of first year students towards chemistry (Appendix A). Results in appendix A also revealed that the observed frequencies of statements 7, 10, 18,19,20,23,27,28 and 40 differ significantly from the expected frequencies at 5% level of confidence.

4.2.1.1 Students' Ratings of Statement

Appendix B gives the percentages and frequencies of students' choice of rating of statements obtained from the instrument that measured the attitudes of first year medical students at a Higher Education Institution in Gauteng towards chemistry on a five point Likert scale.

For the purpose of further analysis the first and last two columns of the Likert scale were collapsed into Disagree and Agree categories as displayed in Figure 2.

The response of the students regarding practical classes.

- The results revealed that 65.0% of students think that laboratory work is not important for medical students, number 38 in Figure 2.
- More than half of the students (53.4%) reported that the practical experiments were not related to the work done in class, number 39 in Figure 2.
- Students, (58.0%) reported that the theory behind experiments was not clearly presented statement 12 in Figure 2
- Most students 59.5% feel that the practical work classes were not stimulating and relevant, number 10 in Figure 2
- Almost the same number of students 57.3% reported that they did not enjoy practical work number 11 in Figure 2.
- And 58.3% said that they do not like chemistry experiments because they can be very dangerous number 14 in Figure 2.

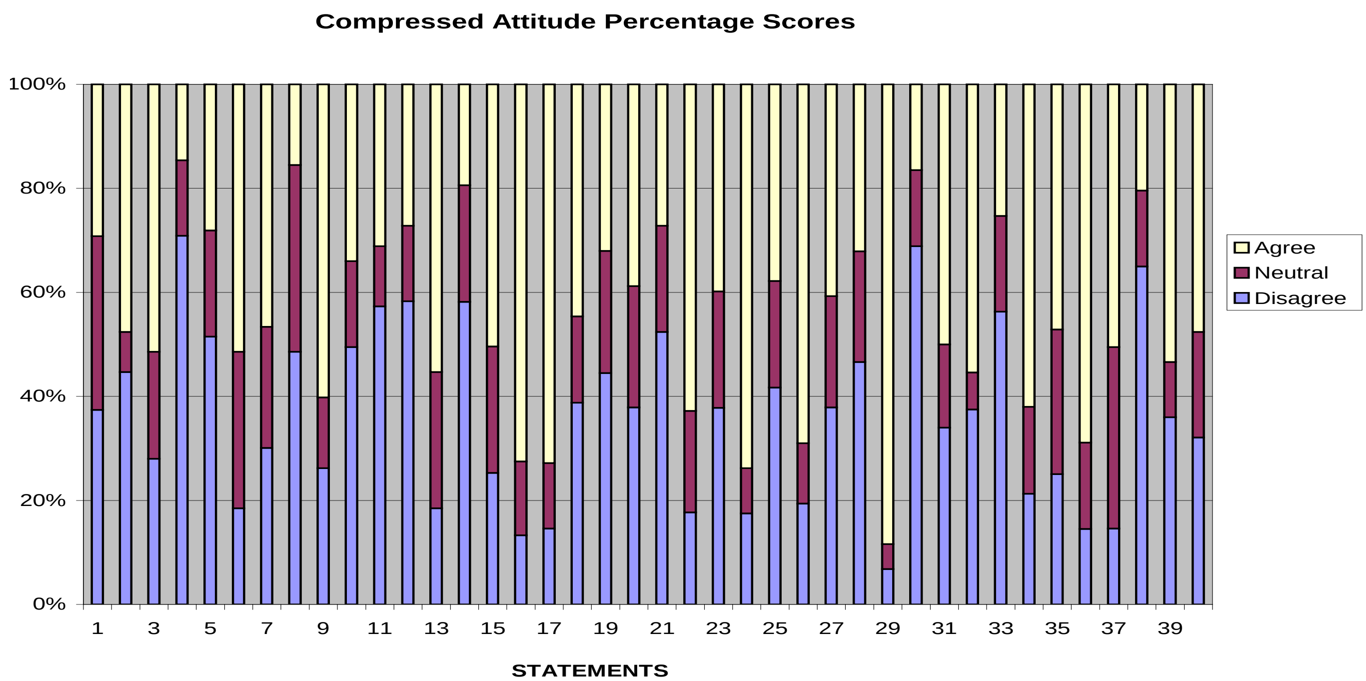

Figure 2 Compressed Percentage Ratings of Statements

The response of the students regarding subject content

- However, 47.6% believed that most of the topics in their syllabus are not useful, number 40 in Figure 2.

The response of the students regarding lecture classes

- Some students (47.6%) reported that chemistry lectures were not interesting or stimulating, number 2 in Figure 2.
- Almost the same proportion of students (46.6%) reported that concepts in lecture materials were not clearly explained, number 28 in Figure 2.
- With 47.6% students saying that they prefer tutorials over lectures, number 35 in Figure 2.

The response of the students regarding chemistry

- Majority of students (70.9%) acknowledged the relevance of chemistry in medicine, number 4 in Figure 2.
- But 69% of these students reported that their main reason for studying chemistry is because it is a prerequisite, number 26 in Figure 2.
- Only 29.2 % of the students reported that chemistry is not their favorite subject, number 14 in Figure 2.
- Less than half of the students (48.6%) think that chemistry is difficult number 8 in Figure 2.
- While 51.4% of them believe that chemistry has created a knowledge base which will help them in their career and during clinical years, number 3 in Figure 2.

The response of the students regarding the lecturer

- Half of students think that their lecturer did not seem to enjoy teaching chemistry, number 31 in Figure 2.
- And 52.4% felt that the lecturer made them feel that they do not have the ability to continue with chemistry number 21 in Figure 2.

The response of the students regarding assessment

- According to 62.1% of students assessment in chemistry is not fair, number 34 in Figure 2.
- Students (50.5%) reported that assessment concentrated mostly on ability to acquire facts than on the development of critical thinking skills, number 37 in Figure 2.
- While (68.9%) would like to have multiple choice questions in the assessment, number 36 in Figure 2.
- Majority of students (73.8%) believe that it is not possible to pass chemistry without understanding number 24 in Figure 2,
- Therefore 88.4% of them feel that it is important for them to understand the work taught in class, number 29 in Figure 2.

4.2.1.2 Total Attitude Scores of Individual Students

In order to establish the attitudes of students toward chemistry the total score of individual students were calculated (Table 4.1) by summing up the ratings of each individual student. Positive attitude is represented by the highest total score and negative attitude by the lowest total score. The maximum possible score for all statements was 200 while the minimum was 40. The overall score for the forty statements had a mean score of 125 and standard deviation of 16.8. The highest total score obtained was 164 which is above the mean score (125) while the lowest total score was 83. The total number of students who scored below the mean score was forty eight (46.6%) from this number 22 (45.8%) were female.

Table 4.1 Total scores of statements ratings of students.

Student	1	2	3	4	5	6	7	8	9	10	11	12	13
Total score	118	132	120	132	142	128	112	139	126	137	138	136	126
Gender	F	F	F	F	F	M	F	F	F	F	M	M	M
Student	14	15	16	17	18	19	20	21	22	23	24	25	26
Total Score	130	129	122	142	115	148	144	116	138	147	115	96	123
Gender	M	M	F	M	M	F	F	F	F	F	M	F	M
Student	27	28	29	30	31	32	33	34	35	36	37	38	39
Total Score	108	107	105	148	132	126	137	105	107	141	136	123	135
Gender	M	F	M	M	F	M	F	M	M	M	F	M	M
Student	40	41	42	43	44	45	46	47	48	49	50	51	52
Total Score	126	140	151	131	129	105	104	110	127	105	125	114	112
Gender	F	F	F	F	M	F	M	M	M	F	M	F	F
Student	53	54	55	56	57	58	59	60	61	62	63	64	65
Total Score	140	165	118	119	115	148	86	123	145	129	121	123	113
Gender	M	F	M	F	F	F	M	F	M	M	M	M	M
Student	66	67	68	69	70	71	72	73	74	75	76	77	78
Total Score	151	112	114	105	105	103	138	124	133	86	141	151	124
Gender	F	F	F	M	F	F	M	M	M	M	F	M	M
Student	79	80	81	82	83	84	85	86	87	88	89	90	91
Total Score	143	137	119	121	85	136	96	137	143	126	157	147	132
Gender	F	M	M	M	M	F	M	M	M	M	F	F	F
Student	92	93	94	95	96	97	98	99	100	101	102	103	
Total Score	124	93	83	142	103	130	141	105	118	130	144	123	
Gender	F	F	M	M	F	M	F	F	M	M	F	M	

4.2.1.3 The spread of attitudes of students

Table 4.2 gives the spread of attitudes of students in four categories. Table 4.2 is organized in such a way that students with a total scores above 180 are regarded as being most positive and those with a total scores of 140 to 180 as being moderately positive, while total scores of 100 to 140 as moderately negative and those scoring less than 100 as being most negative towards chemistry. In Table 4.2 it is demonstrated that there is no student representing the most positive attitude category while the majority of students (70.9%, n=73) are moderately negative towards the learning of chemistry. From these results it is also revealed that the majority of students (77.7%, n= 80) have overall negative attitudes toward chemistry.

Table 4.2 The spread of attitudes scores of students

Total Score	**Attitude Rating**	**% (n) Students**
180+	Strongly Positive	(0)
140-180	Moderately Positive	22.3(23)
100-140	Moderately Negative	70.9(73)
60-100	Strongly Negative	6.8(7)

4.2.1.4 Responses from the open ended questions

Comments that were made by the students have revealed that the qualitative results do not differ much from what has been obtained in the quantitative study. The quantitative results have revealed that most students have negative attitudes toward chemistry. From the statements of students' remarks this is generally due to the way chemistry was taught and assessed, the attitude of the lecturer, the content and mostly the practical work.

The main themes that emerged from the statements given by students indicated that the weaknesses of the department were ineffective way of dealing with students' complains and incompetent lecturers. With regard to teaching, the weaknesses noted were poor student–lecturer interactions, boring teaching methods, lot of content knowledge, practical work which was not related to the lectures and lectures which did not follow the sequence in the prescribe book. In the assessment section students cited unfair marking and allocation of the marks, questions which were not challenging, and delay of feedback from tests and tutorials as weaknesses.

Students suggested that:

- The teaching method used should involve more interaction in class,
- The content knowledge of chemistry for medical students should be revised,
- Lecturers should follow the prescribed book,
- Lecturers should have better attitudes towards students,
- Students' assessment must be marked by more than one assessor, and
- There should be less practical work and more tutorials with fewer students in a group.

4.2.2 Responses to assessment of students' learning outcomes

The examination paper (Appendix F) consisted of 25 items with a total mark of 75. From the examination paper 37 marks (49.3%) were allocated to questions requiring declarative knowledge and 38 marks (50.7%) to questions requiring procedural knowledge. From Appendix C, the highest mean score (0.876, SD=0.3391) was on a question requiring declarative knowledge. In this particular question, 89.3%, (n=108) obtained a mark that is more than half of the mark allocated and only 10.7% (n=13) obtained less than half of the mark allocated to that question.

The lowest mean score (0.0124, SD= 0.1013) was on a question requiring procedural knowledge where 98.3% of students, (n=108) obtained less than half of the allocated mark and only 0.8%, (n=4) obtained half the allocated mark. It is also indicated in Appendix C that students obtained a mean score of above 0.5 in most questions requiring declarative knowledge, however, in some questions on declarative knowledge more than 50% of the students obtained less than half of the allocated mark. This indicates that the students' knowledge was poor in these particular questions.

To obtain the level of students' knowledge on Hailikari's cognitive taxonomy a qualitative analysis of the performance of students in individual questions was employed for selected questions. In answering questions 1.2b and 1.2c it was discovered that majority of students, 89.3%, (n=108) were able to answer question 1.2c but only 3.3%, (n=4) of them were able to solve question 1.2b despite their similarity. The conclusion that could be made is that students might have remembered question 1.2c from previous lessons but were unable to associate it with question 1.2b. In answering question 2.4 a-c, students had an option of recalling familiar names or analyzing the formulas using rules for naming inorganic compounds. Students who used the rules for naming these compounds are expected to be able to answer question 2.4d while those who could not are assumed to have relied on remembering the names of these compounds. In questions 2.4 a-c, 52.1% of the students, (n=63) were able to obtain more than half of the total mark allocated and from this only 28.1% (n=34) were able obtain at least half of the mark allocated to question 2.4d. Students who were able to answer question 2.4a-c but could not answer question 2.4d are assumed to have obtained the correct answer by chance.

Majority of students were able to state Boyle`s law, however from these students only 21.5%, (n=26) could realize the deviation of the experimental results from the law despite the fact that words such as inversely proportional were used in their statements of the law. Similar results were obtained in answering questions 3.2. Majority of students (72.2%) were able to state *Le Chatelier's* principle but could not use it to interpret the observations from an experiment in answering question 3.2. The fact that this large number of students could only state the law but were unable to interpret the experimental data relating to the law could simply mean that students resorted to reproduction of the statements of the laws without understanding their meaning. However if students were operating at a higher cognitive level they would have realized the inconsistency between the law and the given data in 3.1a and they would have been able to answer question 3.2.

Question 3.1b required the application of concepts in which students were suppose to calculate the volume of a gas when the pressure changes given a set of initial volume and pressure at constant temperature. In this question, 87.6% (n=106) obtained more than half the allocated mark. Students who understood what they were writing and who reflected on what they were doing would have realized from the values of the initial and final sets of variables that an increase in pressure is related to the decrease in volume of the gas. By reflecting back on their answers would have enabled most students to make the necessary correction to their mistake in question 3.1a. What could be concluded from this is that majority of students lack understanding and do not reflect on what they are doing. This behavior is usually associated with students who operate at a lower level of cognition.

Questions 3.3a and 3.3b required students to recall stored knowledge. In these questions, 95%, (n=115) and 75.2%, (n=91) respectively scored at least half the allocated mark. There were 43 students (35.5%) who could not answer question 3.3c despite the fact that the answer was given to them indirectly in the question. In this question we can conclude that students who did not answer 3.3c correctly resorted to guessing since the question required them to choose. Guessing is also usually associated with students who operate at the lower level of cognition.

Questions 3.1a and 3.2 required students to interpret results from laboratory experiments. In these questions only 21.5% (n=26) managed to score at least half the allocated mark in question 3.1a and 16.5%, (n=20) in question 3.2. These results clearly indicate that students lack analytical skills associated with practical work.

The responses of students in individual questions have revealed that students have knowledge but they are unable to use acquired knowledge in appropriate situations. The conclusion that could be made about the above results is that students resort to memorization of facts and procedures without understanding concepts. This therefore places them in the lowest level in the declarative knowledge dimension. From Appendix C the mean score in declarative knowledge questions was 29.26% (SD=8.02) and in procedural knowledge questions the mean score was 20.85% (SD=5.71).

It is also indicated in Appendix C that the greater portion of contribution towards the overall performance of the student was from questions on declarative knowledge for most students. However, in 11 cases (9.0%) most contribution towards performance was from questions on procedural knowledge and for 6 cases (5.0%) contribution of questions on declarative knowledge was equal to that of procedural knowledge questions. In 58 cases (47.9%) contribution of the score on declarative knowledge questions was more than that of procedural knowledge by more than 10%. Table 4.5 has also revealed that students numbered 45 and 85 scored the lowest in procedural knowledge questions and has obtained the lowest total mark 21.3% and 30% respectively. Their marks in declarative questions were 13.3% and 22.0% respectively. Students who scored the highest mark in declarative knowledge questions on the other hand scored the highest total mark.

Appendix C revealed that the number of students who scored at least half the total mark of all questions in declarative knowledge questions were 63 (52%) and those who scored at least half the total mark of questions in procedural knowledge were 52 (43%). This implies that majority of students did well in questions on declarative knowledge. The total number of students who achieved the required promotional mark of at least 50% was 63 (52%) of which 31 were female and 32 male. From this number 33 students

(52.4%) obtained less than 50% of the total mark in questions on procedural knowledge. These students will however proceed to the next level of their study where the application of acquired knowledge to new situations is required despite their weak performance in questions on higher cognitive level. This could be used to explain the high failure rate of medical students in chemistry related subjects in higher levels.

4.2.3 Relationship of students' attitude scores and their learning outcomes

The results indicating the relationship of performance of students in each knowledge component and their attitude scores are displayed in Appendix D.

The minimum total mark obtained in declarative knowledge questions was 5.3% the corresponding attitude score was 86, this score falls in the most negative category. The maximum total mark was 48.0% the corresponding attitude score was 151, this score falls in the moderately positive category. In procedural knowledge questions the minimum total mark obtained was 8.0% the corresponding attitude score was 105, this score falls in the most negative category. The maximum total mark obtained was 34.0% the corresponding attitude score was 141, this score falls in the most positive category. The student who obtained the minimum mark in declarative knowledge questions scored higher in procedural knowledge questions (17.4%). On the other hand the student who scored higher in declarative knowledge questions scored lower in procedural knowledge questions (26.7%). While the student who obtained the maximum total mark in procedural knowledge questions scored more in declarative knowledge questions (38.0%) than in procedural knowledge questions. From these results one can conclude that students who have an understanding of concepts have a better chance of putting their knowledge to better use.

4.2.3.1 Correlation Analysis

Pearson's correlation analysis results for the relationship between students' attitudes towards chemistry and their performance in different knowledge components are displayed in Table 4.3. The results of the relationship between students' attitudes and their learning outcomes on the basis of their performance in declarative knowledge and procedural knowledge questions showed that all three variables are inter-correlated. These correlations are positive and moderately significant.

Table 4.3 Correlation between attitudes towards chemistry with performance in different knowledge components.

Variable	Attitude	Declarative r	Procedural
Attitude	1.000	0.617*	0.485*
Declarative	0.617*	1.000	0.450*
Procedural	0.485*	0.450*	1.000

*P< .01

The multiple-correlation was 0.659 which is a moderate correlation. The ANOVA results showed a significant relationship between attitude scores and scores in the two knowledge components (F=38.382, P=.000). The results suggest that improving the attitudes of students towards chemistry could improve their learning outcomes in both knowledge components.

4.2.3.2 Regression Analysis

Multiple linear regression analysis was employed to establish the variable that is a statistically significant predictor of attitudes of students. The results in Table 4.4 show the regression analysis of attitudes as the dependent variable and the two independent variables (declarative knowledge and procedural knowledge).

Table 4.4 Summary of multiple regression analysis: different knowledge components predicting attitudes

Explanatory Variable	B	SEB	Beta	t	sig.
Attitude	78.090	5.613	-	13.914	0.000
Declarative	1.056	0.178	0.500	5.936	0.000
Procedural	0.770	0.250	0.260	3.084	0.003

The results in Table 4.4 show that declarative knowledge and procedural knowledge components are statistically significant predictors accounting for 43% variance in students’ attitudes towards chemistry.

The standardized regression coefficient for declarative knowledge was 1.056 and 0.770 for procedural knowledge. These values show that declarative knowledge component is a better predictor of attitude than procedural knowledge component. Both variables, however, were positively and significantly related to attitude ß=.500, P=.000 for declarative knowledge and ß=.26, P=.000 for procedural knowledge. These results show that attitudes of students will affect students' performance in both knowledge components.

4.2.4 Relationship of overall performance score of students and their performance in declarative and procedural knowledge components.

4.2.4.1 Correlation Analysis

Pearson's correlation analysis results for the relationship between students' overall performance and their performance in different knowledge components are displayed in Table 4.5.

Correlations observed among these variables showed that the relationship of declarative knowledge, r=.901 and procedural knowledge components, r=.790 with overall performance are highly correlated. However, the correlation between declarative knowledge component and procedural knowledge component was moderate, r=0.450.

Table 4.5 Correlations between performance in chemistry with performance in different knowledge components.

Variable	Performance	Declarative r	Procedural
Performance	1.000	0.901*	0.790*
Declarative	0.901*	1.000	0.450*
Procedural	0.790*	0.450*	1.000

*P< .01

4.2.4.2 Regression Analysis

Multiple regression analysis was employed to establish the relationship between overall performance and knowledge components. Results are displayed in Table 4.6.

Table 4.6 Summary of Regression Analysis: Different knowledge components predicting overall score

N=103

Explanatory Variables	B	SEB	Beta	t	sig.
Performance	0.213	0.216	-	0.81	0.418
Declarative	1.002	0.008	0.684	120.893	0.000
Procedural	0.990	0.012	0.482	85.116	0.000

The results of the prediction of performance on the basis of performance in declarative knowledge and procedural knowledge questions showed that all three variables are inter-correlated and all these correlations are significant (Table 4.6). The ANOVA results shows a significant relationship between performance and the two knowledge components (F=19511.226, P=.000). The standardized regression coefficient for declarative knowledge was 1.002 and for procedural knowledge 0.990. These values show that declarative knowledge component is a better predictor of overall performance than procedural knowledge component. Both variables, however, were positively and significantly related to overall performance.

4.3 Conclusion

In this chapter the empirical results have shown that majority of students have negative attitudes towards chemistry and their learning outcomes is on the declarative level. It was also shown that rating students based on their overall achievement score is not a good idea of assessing students. There is therefore a need to address factors influencing attitudes of students and to assess students objectively. In chapter 5 summaries conclusions and recommendations regarding the implications of the results of this study to teaching and learning will be made.

CHAPTER 5

Discussion of the Results, Recommendations and Conclusion

5.1 Introduction

The present chapter provides the discussion of the results, recommendations based on the findings from the results and conclusion. In the discussion of the results the findings emanating from this study will be highlighted and compared with findings from previous similar work. Suggestions that will help in the improvement of teaching and learning will be provided as recommendations. The section on conclusion will be limited to suggestions relating to teaching and learning at university of Limpopo and the implications of this study to the education in general. The study focused on medical students at a Higher Educational Institution in Gauteng only and the results can therefore not be generalized to include students at other higher institutions.

5.2 Discussion of the Results

The purpose of the study was to assess the relationship of attitude of first year medical students at a Higher Education Institution at Gauteng in chemistry and their learning outcomes. This was accomplished by assessing students' attitudes using a self developed chemistry attitude questionnaire and an examination which was designed using Hailikari's model of prior knowledge. The background of the students and a literature review were used to provide a conceptual framework that was used to address the problem. From the results it was revealed that students' performance in chemistry is mostly due to their good performance in questions requiring factual knowledge than in questions requiring procedural knowledge. This could be associated with the fact that when they proceed with their studies they are unable to use this knowledge which is stored as isolated fragments.

The findings emanating from the analysis of the results are as follows:

The results of this study have revealed that medical students at the Higher Education Institution in this study have negative attitudes towards chemistry. In chapter 2 several variables from previous studies were found to influence the attitudes of students towards science in general. In the current study the analysis of results indicated that factors such as the teaching method, the lecturer, laboratory practical work, assessment and content are among factors that affect the attitude of first year students in this study towards chemistry.

The study of Anvik *et al*. (2007) on medical students at medical schools in Norway had revealed that medical students at Norway also have negative attitudes towards a subject from another field. According to Anvik *et al*. 2007 the negativity of students in medical schools in Norway towards communication skills was not because they are not aware of the benefits of using these skills when seeing patients but because of the way such skills were taught. The same was also evident in this study when majority of students were shown to have negative attitude towards chemistry despite reporting that chemistry is definitely important in medicine. Mostert (2006) also discovered that medical students at Stellenbosch University, South Africa had negative attitudes towards biostatistics because of content and the way it was taught. Students at Stellenbosch University regarded the subject content as strictly statistics with no relevance to their field of study.

The effect of teaching method on students' attitudes in this study was revealed in both the open and close ended questions. As indicated in chapter 2 some researchers are also not in favour of lecture as a teaching method they blame this teaching strategy for the negative reactions of students towards a subject and its inability to cultivate transferable skills to students. In the study of Tynjälä (1999) a comparison between students in the constructivist learning environment and in a traditional learning environment were made and the results have shown that students in the constructivist learning environment acquired more diversified knowledge than in the traditional learning environment. The effect of instructional strategy on acquisition of knowledge and attitude was also reported by Klein & Schnackenberg (2000). The study of Ye; Skoog and Zhu (2000) on Chinese secondary school students yielded contradicting results. In their study it was shown that teaching method does not have a significant influence on students' achievement and attitudes towards science learning. This was also confirmed by Ebenezer & Zoller (1993) who found out that teaching method has no effect on students' attitudes towards science teaching in spite of using the constructivist approaches which is highly recommended as an effective teaching strategy. The difference in results from these studies could be the fact that different approaches are needed for different topics of the same subjects. It is therefore recommended that the teaching method used should be dictated by the learning objective and this must correlate with assessment method used.

Many researchers in education believe that using a single teaching method is relatively ineffective and not stimulating to students. Students in this study declared the lecture method as not stimulating and recommended a teaching method that would involve them more. The ineffectiveness of the lecture method was revealed in the results of this study where students were awarded a pass rating despite their inability to display a satisfactory performance in questions on procedural knowledge. Innovative approaches in teaching are therefore required to complement any teaching method especially in large group of students where the lecture method is most appropriate. These methods should also be accompanied by assessment strategies that support cognitive growth of students to higher levels.

In the open ended questionnaire some students indicated that the syllabus should be reviewed. Some students also commented that some topics are irrelevant for them as medical students. This could be due to the lack of using examples and situations in the medical context which could be associated with the traditional teaching method. It is therefore recommended that an interdisciplinary curricular and an integrative learning style should be employed in order to assist students to realize the link between different disciplines. This could help students to relate what they have learned in class to situations encountered in everyday life. Lecturers should aim at covering the depth instead of the breadth of any subject matter and help advance knowledge of students to higher levels. It is therefore recommended that students should be taught using methods that incorporate interactive engagement of students which will require that students should also take the responsibility of learning outside of class to retain course content.

Majority of students indicated that they were only studying chemistry because it is a requirement. The same observation was made by Smith in Cook & Mulvihill (2008) who revealed that most non-science majors enroll in science courses to fulfill a general education or major requirement and not because they have a personal interest in science. This will therefore require that science teachers who are teaching non-science students should make science to be stimulating and fun to them for them to have desirable attitudes. This was also revealed in the study of Young (2002) who showed that students who chose to study science as their specialist subject had a much more positive attitude towards science than those who were obliged to include it in their curriculum.

Majority of students expressed a negative feeling towards practical work with some stating that chemistry practical work is not important for medical students. The use of expository teaching strategy for laboratory classes has been criticized for its lack of advancing students to higher cognitive levels. This was confirmed in this study when students were unable to interpret experimental data or notice irregularities in practical data. In the study of Kaya, (2005) students at universities at Ankara, Turkey, developed better attitudes toward chemistry laboratory work after using the method that enabled them to construct new knowledge from their experiences in the laboratory. This method has also been proved to improve students' conceptual understanding. Researchers have indicated that practical work should be a meaningful activity that supports theoretical concepts from the lecture classes and if this is done through verification method of teaching this is unlikely to be achieved. Students have also indicated that the theory explained in classes did not support the laboratory practical experiments. The performance of the students in practical work also did not reflect their understanding of the work done. The performance of students indicated lack of analytical reasoning which according to Kitchen, Bell, Reeve, Sudweeds & Bradshaw, (2003) is not possible unless hands-on laboratory experience, instructional methods and assessment specifically designed to foster it are employed. This was shown in the examination paper when majority of students were unable to interpret experimental data in answering one of the questions. Davis, (2004) indicated that students hold different views about the problems and benefits of chemistry practicals and therefore recommended that these should be taken into consideration when developing chemistry program.

Preparation for a profession requires the integration of theoretical and practical knowledge. Studies have shown that knowledge acquisition process starts early in infancy and is based on interpretations of everyday experience. If the knowledge base of our medical practitioners is at the lowest level we are likely to have doctors who are able to save the lives of patients with heart attacks by performing CPR on them but are unable to save their own lives when faced with the same situation because they do not understand the underlying concept behind CPR. According to Wiggins & Mc Tighe in Tanner & Allen (2005) when students understand they will then be able to explain, interpret and apply acquired knowledge. Other studies have revealed that students' attitudes are improved when they are able to see the relevance of a subject to their field of study.

Assessment is an integral part of learning which also needs particular consideration in order to support the learning process. Several studies have revealed that assessment that emphasize factual knowledge results in “clutter of inert ideas which students are not able to use effectively in familiar context and creatively in open ended problem solving situations”. In the current study most students learned by reproduction of concepts rather than through the understanding of concepts. This was illustrated by questions 1b and 1c where similar questions were asked but a significantly large number of students were able to answer one question but not the other. In questions 2.4a-c and 2.4d students who used knowledge of procedures and not reproduction of knowledge should have been able to answer both these questions. The results however gave a different proportion of students who were able to answer both these questions correctly. This indicated that those students who were able to answer one but not the other question operated at the lower level of cognition.

The results of the relationship between attitude scores of students and their scores in the two knowledge components were significant. This showed that attitude of students will affect their performance in both knowledge components if the knowledge base of students is not advanced. The study of Yücel (2007) also indicated a significant connection between students’ achievement and attitudes towards chemistry. Kan & Akbas (2005) and Morgil, Seyhan, Alsan & Temel, (2008) obtained similar results. Papanastasiou & Zembylas (2002) obtained similar results and their conclusion was that students’ science attitudes do influence their actual performance in science while their science achievement does not necessarily influence their attitudes. The results of the study of Cracker (2006) revealed a strong relationship between attitude toward science and expected achievement. Liu & Hsieh (2006) on the other hand found out that attitude was not a statistically significant predictor of science achievement. The difference in effect of attitude towards performance of students in the above studies could be because of the type of questions in the assessment. In the current study it was shown that students with declarative knowledge base have better attitudes towards chemistry than those possessing procedural knowledge. This could be due to the fact that some students feel more confident when they have more factual knowledge than when they have limited knowledge even if they are unable to use the acquired knowledge.

A high correlation was observed among the relationship of declarative knowledge and procedural knowledge with overall performance. Correlation of declarative knowledge with procedural knowledge was positive but weak. Of the two knowledge components declarative knowledge was a more significant predictor of performance than procedural knowledge component. In the study of Hailikari, Nevgi, & Lindblom-Ylanne (2007) it was shown that the type of knowledge makes a difference in the overall performance of the students. However, it was also shown that measures assessing procedural knowledge were able to predict final grades while those measuring declarative knowledge did not predict final grades, the opposite was obtained in the current study. The results of this study can be justified by noting that students have to first recall relevant information before they can apply, analyze or integrate knowledge. According to Tan (1992) high level conceptual understanding is required for students to be able to integrate the basic and clinical sciences. Students who are only able to recall the stored knowledge will therefore have difficulties in applying that knowledge in appropriate situations.

5.3 Limitations of the Study

Some limitations were experienced in the current study. Opinions from senior medical students were desired however the students were not made part of the study. Opinions from these students would have provided a broader view to the general attitude of medical students. The scope of the examination was only based on the general part of chemistry and not on the organic part. Having examinations from both sections would have provided a better explanation of the knowledge base of students in chemistry as a whole. The basic knowledge of organic chemistry is required in subjects as physiological chemistry, pharmacology, biochemistry and others which form part of the medical curriculum. The performance of students in organic chemistry would have provided some information which could explain why there is such a high failure rate in chemistry related courses in medicine.

5.4 Recommendations and Conclusion

The knowledge of subjects such as chemistry and biology are necessary for medical students in order for them to understand and appreciate the concepts in physiology and clinical subjects. Based on this fact, it is therefore important for lecturers teaching these subjects to involve lecturers in the medical field when selecting the content for these subjects. Seeing that the extent of chemistry is vast it will also be advisable for chemistry lecturers to limit its instruction to that portion which will be of real use to the student in the practice of his profession. To improve quality of our students, instruction should focus on enhancing students cognitive and affective skills including domain specific knowledge in subject matter domain instead of merely memorizing concepts and principles. Students should be taught how to use acquired knowledge and integrate prior knowledge with new knowledge in a meaningful way. This will help in instilling desirable attitudes to students and in helping them to have a better understanding of chemistry in the context of medicine.

Since the issue of large number of students will always be a factor, chemistry lecturers should compliment lecture method with innovative teaching styles that will not only stimulate students but will encourage retention and use of acquired knowledge. This study has brought forth information that has implications for assessment in general. It is therefore recommended that these teaching methods will require fundamental changes in assessment procedures. During the process of development of programs alternative assessment procedures involving challenging authentic activities should be among the most important tasks.

In teaching and learning there are different methods used to evaluate the learning outcomes of students. The most appropriate method should include different tasks to measure different forms of knowledge. The tasks selected should enable students to shift from one knowledge level to the next. The problem of being able to only perform at the lowest cognitive level is that students will not be able to make use of the acquired knowledge. The results of this study suggest that it would be beneficial for the student if assessment could be based on questions that are able to advance their knowledge base from one level to the next. If this is done students would be able to transfer knowledge gained in one discipline to the other. The results could also be used to select appropriate learning environments that could improve the attitudes and understanding of chemistry as a supporting subject to students from other disciplines.

Most science academics are scientists with no or little pedagogical training. As research continues new models of learning and their implications towards teaching are discovered. It is therefore recommended that pedagogical training should be included in the educational support of academics. This will help academics in selecting appropriate methods for different groups of students and different assessments for different learning outcomes. If positive attitudes of students are desired researchers suggest that lecturers should have positive attitudes towards students and the subject they are teaching. It is therefore recommended that in appointing lecturers it is important to choose lecturers who are not only knowledgeable but are also enthusiastic about their teaching.

Knowing our students’ attitudes towards science and the effect they can have on their learning outcomes can enhance our quality of teaching. While knowing their knowledge level will indicate to us the quality of professionals that we are producing. This will also help us to identify the gaps in students’ knowledge. This study could also be used to provide guidelines to the policy makers and assessment standards authorities as to how performance of students should be measured.

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APPENDICES

Appendix A: Descriptive analysis results of attitude statements of first year students

Variables	Mean	Standard Deviation	Lower Bound	Upper Bound	χ^2 / p-value
1	2.7864	1.22595	2.5468	3.0260	18.990 / .001
2	2.7087	1.34770	2.4453	2.9721	15.204 / .004
3	3.2330	1.30010	2.9789	3.4871	17.922 / .001
4	3.8447	1.23477	3.6033	4.0860	43.165 / .000
5	2.5437	1.34147	2.2815	2.8059	12.874 / .012
6	3.4078	1.19178	3.1748	3.6407	26.272 / .000
7	2.7087	1.26515	2.4615	2.9560	8.699 / .069
8	2.4175	1.11605	2.1994	2.6356	34.330 / .000
9	3.3981	1.39565	3.1253	3.6708	24.233 / .000
10	3.1845	1.39851	2.9111	3.4578	5.883 / .208
11	2.4563	1.42648	2.1775	2.7351	25.592 / .000
12	2.3786	1.32928	2.1188	2.6384	26.757 / .000
13	3.5243	1.17026	3.2956	3.7530	24.816 / .000
14	3.5243	1.25123	3.2797	3.7688	22.291 / .000
15	3.3824	1.35737	3.1157	3.6490	11.039/ .026
16	3.6961	1.08809	3.4824	3.9098	78.490 / .000
17	3.8641	1.10301	3.6485	4.0797	50.350 / .000
18	3.0194	1.44154	2.7377	3.3012	3.650 / .455
19	2.7864	1.28071	2.5361	3.0367	6.653 / .161
20	3.0485	1.33121	2.7884	3.3087	2.777 / .596
21	2.4608	1.41191	2.1835	2.7381	27.118 / .000
22	3.5980	1.14546	3.3730	3.8230	36.137 / .000
23	2.9515	1.34586	2.6884	3.2145	1.806 / .771
24	2.1068	1.39265	1.8346	2.3790	61.126 / .000
25	2.8252	1.43778	2.5442	3.1062	11.417 / .022
26	3.7282	1.30755	3.4726	3.9837	36.175 / .000
27	3.0680	1.27003	2.8197	3.3162	8.117 / .087
28	2.7087	1.34041	2.4468	2.9707	6.175 / .186
29	4.3107	.91854	4.1312	4.4902	106.078 / .000
30	3.6893	1.23692	3.4476	3.9311	43.359 / .000
31	2.6961	1.60315	2.3812	3.0110	22.608 / .000
32	2.4951	1.55849	2.1906	2.7997	37.437 / .000
33	3.5631	1.38387	3.2926	3.8336	19.1987 /

					.001
34	2.1845	1.39148	1.9125	2.4564	57.631 / .000
35	3.8137	1.39823	3.5391	4.0884	11.515 / .021
36	3.9126	1.28419	3.6616	4.1636	51.903 / .000
37	3.5243	1.08325	3.3126	3.7360	33.165 / .000
38	3.6019	1.31611	3.3447	3.8592	28.796 / .000
39	3.1553	1.45358	2.8713	3.4394	15.592 / .004
40	3.1845	1.44675	2.9017	3.4672	5.107 / .277

Appendix B The Percentage/frequencies of students' choice of rating of statements

Questionnaire Statement	Percentage/ Number of Students Choosing Rating				
	SD	D	N	A	SA
1. Chemistry is my favorite subject.	21.9/22	15.5/16	34.0/35	21.4/22	7.8/8
2. I do not find chemistry lectures to be interesting and stimulating.	16.5/17	28.2/29	7.8/8	28.2/29	19.4/20
3. The subject has created a knowledge base which will help me in my career.	15.5/16	12.6/13	20.4/21	35.9/37	15.5/16
4. Chemistry is not relevant to my field of study.	36.9/38	34.0/35	14.6/15	6.8/6	7.8/8
5. Chemistry has helped me to develop my problem solving and reasoning skills.	31.1/32	20.4/21	20.4/21	19.4/20	8.7/9
6. Chemistry will help me during my clinical years of study.	10.7/11	7.8/8	30.1/31	33.0/34	18.4/19
7. I do not do well in chemistry.	8.7/9	21.4/22	23.3/24	25.2/26	21.4/22
8. Chemistry is easy for me.	28.2/29	20.4/21	35.9/37	12.6/13	2.9/3
9. Tutorial sessions helped me to understand the lecture course.	17.5/18	8.7/9	13.6/14	36.9/37	23.3/24
10. Practical sessions are not stimulating and relevant to my field of study.	17.5 /18	16.5/17	16.5 /17	20.4 /21	29.1/30
11. I enjoy doing chemistry practicals.	37.9/39	19.4 /20	11.7/12	21.4 /22	9.7/10
12. The theory behind the experiments was clearly presented.	36.9/38	21.4 /22	14.6/15	21.4 /22	5.8/6
13. I am good at practical wok.	7.8 /8	9.7 /10	27.2/28	33.0/34	22.3/23
14. I do not like practicals because they can be very dangerous.	10.7/11	8.7/9	22.3/23	34.0/35	24.3/25
15. I have a real desire to learn chemistry	14.7/15	9.8/10	23.5/24	26.5 /27	25.5/26
16. Learning chemistry requires that I substantially rethink, restructure and reorganize the information that I am given.	7.8/8	5.9/6	13.7/14	53.9/55	18.6/19
17. When learning chemistry I prefer to put concepts in my own words.	3.9/4	10.7/11	12.6/13	40.8/42	32.0/33
18. Lecture notes are more useful than my own notes	22.3/23	16.5/17	16.5/17	26.2/26	18.4/19
19. Concepts in chemistry are difficult to understand	19.4/20	25.2/26	23.3/24	21.4/22	10.7/11
20. My problem with chemistry is being able to memorize all the information I need to know.	14.6/15	23.3/24	23.3/24	20.4/21	18.4/19
21. The chemistry lecturers have made me feel that I have the ability to continue in science.	39.8/41	12.6/13	20.4/21	17.5/18	9.7/10
22. A good understanding of chemistry is necessary for me to achieve my career goals.	6.9/7	10.8/11	19.6/20	41.2/42	21.6/22
23. You cannot have an understanding of chemistry by	15.5/16	22.3/23	22.3/23	21.4/22	18.4/19

memorizing things you have read or been taught in class.					
24. It is not possible to pass chemistry without understanding.	13.6/14	3.9/4	8.7/9	27.2/28	46.6/48
25. Learning chemistry has helped me to understand situations in my everyday life.	29.1/30	12.6/13	20.4/21	25.2/26	12.6/13
26. The main reason I am doing chemistry is because it is a prerequisite for my course.	10.7/11	8.7/9	11.7/12	35.0/36	34.035
27. Theories in chemistry are very abstract and very difficult to comprehend.	11.7/12	26.2/27	21.4/22	25.2/26	15.5/16
28. The concepts introduced in the lecture materials are clearly explained.	25.2/26	21.4/22	21.4/22	21.4/22	10.7/11
29. It is important for me to understand the work taught in class.	1.9/2	4.9/5	4.9/5	36.9/38	51.5/52
30. I cannot see the relation between chemistry and medicine.	27.2/28	41.7/43	14.6/15	5.8/6	10.7/11
31. My chemistry lecturer did not seem to enjoy teaching chemistry.	22.5/23	11.8/12	15.7/16	12.7/13	37.3/38
32. The teaching method used in class is not stimulating.	15.5/16	17.5/18	11.7/12	11.7/12	43.7/45
33. My lecturers presented the material in a clear way.	35.9/37	20.4/21	18.4/19	14.6/15	10.7/11
34. The assessment system in chemistry is not fair.	8.7/9	12.6/13	16.5/17	12.6/13	49.5/51
35. I prefer tutorials than lectures.	13.6/14	10.7/11	28.2/29	23.3/24	24.3/25
36. I would like multiple choice questions to be included in the assessment.	8.7/9	5.8/6	16.5/17	23.3/24	45.6/47
37. The assessment concentrates on ability to acquire facts rather than on the development of critical thinking skills.	4.9/5	9.7/10	35.0/36	29.1/30	21.4/22
38. Chemistry laboratory work is not important for medical students.	10.7/11	9.7/10	14.6/15	35.9/37	29.1/30
39. The practical experiments are not related to lectures.	20.4/21	15.6/16	10.7/11	34.0/35	19.4/20
40. Most of the topics in chemistry are not useful.	20.4/21	11.7/12	20.4/21	24.3/25	23.3/24

Appendix C Scores of students' learning outcomes

				Number of students scoring (%)		
Assessment	Knowledge Base	Mean Score	SD	< 0.5	0.5	>0.5
1.1	Declarative knowledge	0.5124	0.39509	36 (29.8)	46 (38.0)	39 (32.2)
1.2a	Declarative knowledge	0.2314	0.41353	90 (74.4)	5 (4.1)	26 (21.5)
1.2b	Declarative knowledge	0.0702	0.23546	111 (91.7)	6 (5.0)	4 (3.3)
1.2c	Declarative knowledge	0.876	0.33091	13 (10.7)	0 (0)	108 (89.3)
1.3	Declarative knowledge	0.7769	0.35326	13 (10.7)	25 (20.7)	83 (68.6)
1.4	Procedural knowledge	0.1942	0.39461	98 (81)	1 (0.8)	22 (18.2)
1.5a	Declarative knowledge	0.4256	0.45489	52 (43)	27 (22.3)	42 (34.7)
1.5b	Declarative knowledge	0.405	0.4844	70 (57.9)	4 (3.3)	47 (38.8)
1.5c	Procedural knowledge	0.7645	0.4035	25 (20.7)	8 (6.6)	88 (72.7)
2.1a	Declarative knowledge	0.5207	0.46752	52 (43.0)	14 (11.6)	55 (45.4)
2.1b	Declarative knowledge	0.3223	0.46485	81 (66.9)	2 (1.7)	38 (31.4)
2.2a	Procedural knowledge	0.5785	0.46551	44 (36.4)	14 (11.6)	63 (52.1)
2.2b	Declarative knowledge	0.405	0.49293	72 (59.5)	0 (0)	49 (40.5)
2.2c	Procedural knowledge	0.8554	0.34423	16 (13.2)	3 (2.5)	102 (84.3)
2.3	Procedural knowledge	0.0124	0.1013	119 (98.3)	1 (0.8)	1 (0.8)
2.4a-c	Declarative knowledge	0.6322	0.42214	31 (25.6)	27 (22.3)	63 (52.1)
2.4d	Declarative knowledge	0.3099	0.44841	80 (66.1)	7 (5.8)	34 (28.1)
3.1a	Procedural knowledge	0.3554	0.4002	61 (50.4)	34 (28.1)	26 (21.5)
3.1b	Procedural knowledge	0.8182	0.3873	15 (12.4)	0 (0)	106 (87.6)
3.1c	Declarative knowledge	0.7521	0.43361	22 (18.2)	0 (0)	99 (81.8)
3.2	Procedural knowledge	0.2769	0.41808	88 (72.7)	13 (10.7)	20 (16.5)

3.3a	Declarative knowledge	0.719	0.45135	6 (5.0)	0 (0)	115 (95.0)
3.3b	Declarative knowledge	0.7438	0.43835	16 (13.2)	14 (11.6)	91 (75.2)
3.3c	Declarative knowledge	0.6074	0.47525	43 (35.5)	7 (5.8)	71 (58.7)
3.4	Procedural knowledge	0.4174	0.48882	62 (51.2)	11 (9.1)	48 (39.7)

Appendix D Performance of students in each knowledge category, and attitude scores of individual students according to gender

Student	Declarative Knowledge scores %	Procedural Knowledge scores %	Total score %	Attitude score	Gender
1	24.7	10.0	34.7	118	F
2	32.0	22.0	54.0	132	F
3	25.3	19.3	44.7	120	F
4	35.3	19.3	54.7	132	F
5	37.3	25.3	62.7	142	F
6	26.0	16.7	42.7	128	M
7	30.7	18.7	49.3	112	F
8	30.0	19.3	49.3	139	F
9	44.0	24.0	68.0	126	F
10	42.7	26.0	68.7	137	F
11	30.7	21.3	52.0	138	M
12	32.7	29.3	62.0	136	M
13	33.3	27.3	60.7	126	M
14	36.7	26.0	62.7	130	M
15	28.7	24.7	53.3	129	M
16	28.7	17.3	46.0	122	F
17	46.7	18.7	65.3	142	M
18	22.7	14.7	37.3	115	M
19	38.0	24.7	62.7	148	F
20	35.3	24.7	60.0	144	F
21	24.0	24.0	48.0	116	F
22	34.0	31.3	65.3	138	F
23	40.0	23.3	63.3	147	F
24	32.7	18.7	51.1	115	M
25	10.7	13.3	24.0	96	F
26	23.3	18.0	41.3	123	M
27	19.3	20.0	39.3	108	M
28	21.3	21.3	42.7	107	F
29	15.3	13.0	28.7	105	M
30	42.0	30.0	72.0	148	M
31	34.7	26.7	61.3	132	F
32	38.7	28.7	67.7	126	M
33	17.3	28.0	45.3	137	F
34	28.0	21.3	49.3	105	M
35	21.0	20.7	42.0	107	M
36	38.0	34.0	72.0	141	M
37	22.7	21.3	44.0	136	F
38	25.3	27.3	52.7	123	M
39	29.3	26.7	56.0	135	M

40	21.3	17.3	38.7	126	F
41	34.7	24.0	58.7	140	F
42	48.0	26.7	74.7	151	F
43	34.7	18.7	53.3	131	F
44	29.3	12.7	42.0	129	M
45	13.3	8.0	21.3	105	F
46	32.0	19.3	51.3	104	M
47	27.3	22.0	49.3	110	M
48	37.3	20.7	58.0	127	M
49	35.3	24.0	59.3	105	F
50	37.3	20.0	57.3	125	M
51	23.3	16.0	39.3	114	F
52	28.0	22.0	50.0	112	F
53	32.0	22.0	54.0	140	M
54	36.0	12.7	48.7	165	F
55	21.3	18.0	39.3	118	M
56	37.3	18.7	56.0	119	F
57	24.7	20.7	45.3	115	F
58	36.0	12.7	48.7	148	F
59	18.7	10.7	29.3	86	M
60	30.0	23.3	53.3	123	F
61	33.3	28.0	61.3	145	M
62	21.3	9.3	30.7	129	M
63	20.0	20.0	40.0	121	M
64	39.3	24.0	63.3	123	M
65	25.3	12.7	38.0	113	M
66	42.7	26.0	68.7	151	F
67	20.0	25.3	45.3	112	F
68	20.7	19.3	40.0	114	F
69	26.0	17.3	43.4	105	M
70	26.7	22.0	48.7	105	F
71	14.7	14.0	28.7	103	F
72	40.0	23.3	63.3	138	M
73	34.7	20.0	54.7	124	M
74	37.3	18.7	56.0	133	M
75	5.3	17.4	22.7	86	M
76	37.3	24.0	61.3	141	F
77	32.7	33.3	66.0	151	M
78	30.7	17.3	48.0	124	M
79	28.0	28.0	56.0	143	F
80	40.0	28.7	68.7	137	M
81	26.7	28.0	54.7	119	M
82	20.0	16.0	36.0	121	M
83	24.7	20.0	44.7	85	M
84	28.7	18.7	47.3	136	F

85	22.0	8.0	30.0	96	M
86	20.0	22.7	42.7	137	M
87	30.7	28.0	58.7	143	M
88	29.3	17.3	46.7	126	M
89	31.3	32.0	63.3	157	F
90	30.7	27.3	58.0	147	F
91	29.3	24.7	54.0	132	F
92	24.0	14.7	38.7	124	F
93	27.3	17.3	44.7	93	F
94	30.7	13.3	44.0	83	M
95	34.7	22.7	57.3	142	M
96	16.0	27.3	43.3	103	F
97	33.3	20.0	53.3	130	M
98	28.0	20.7	48.7	141	F
99	18.7	12.0	30.7	105	F
100	20.7	10.7	31.3	118	M
101	32.7	17.3	50.0	130	M
102	29.3	16.0	51.3	144	F
103	38.0	17.3	55.3	123	M

Appendix E: One –Sample Test for mean difference of learning outcomes

Question	Test Value = 0					
					95% Confidence Interval of the Difference	
	T	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
1.1	14.266	120	.000	.51240	.4413	.5835
1.2a	6.155	120	.000	.23140	.1570	.3058
1.2b	3.282	120	.001	.07025	.0279	.1126
1.2c	29.120	120	.000	.87603	.8165	.9356
1.3	24.190	120	.000	.77686	.7133	.8404
1.4	5.414	120	.000	.19421	.1232	.2652
1.5a	10.292	120	.000	.42562	.3437	.5075
1.5b	9.196	120	.000	.40496	.3178	.4921
1.5c	20.841	120	.000	.76446	.6918	.8371
2.1a	12.257	120	.000	.52066	.4366	.6048
2.1b	7.627	120	.000	.32231	.2386	.4060
2.2a	13.670	120	.000	.57851	.4947	.6623
2.2b	9.037	120	.000	.40496	.3162	.4937
2.2c	27.334	120	.000	.85537	.7934	.9173
2.3	1.346	120	.181	.01240	-.0058	.0306
2.4a-c	16.474	120	.000	.63223	.5562	.7082
2.4d	7.603	120	.000	.30992	.2292	.3906
3.1a	9.768	120	.000	.35537	.2833	.4274
3.1b	23.238	120	.000	.81818	.7485	.8879
3.1c	19.079	120	.000	.75207	.6740	.8301
3.2	7.284	120	.000	.27686	.2016	.3521
3.3a	17.523	120	.000	.71901	.6378	.8002
3.3b	18.665	120	.000	.74380	.6649	.8227
3.3c	14.060	120	.000	.60744	.5219	.6930
3.4	9.392	120	.000	.41736	.3294	.5053

Appendix F: Instrument to Assess Chemistry Learning Outcomes of First Year Medical Students

Question 1

1.1 Define the following terms

(a) pure substance

(b) solution. (2)

1.2 (a) Which technique is used to prepare a dilute solution from a concentrated solution? (1)

(b) How would you prepare 100ml of 0.9 % saline solution from 10 % saline solution? (3)

(c) An order of medication reads: “give 0.04 ml per kilogram of body weight.” How much medication should be given to a patient weighing 85 kg? (4)

1.3 Define the following terms as used in chemistry

(a) atomic mass

(b) atomic number

(c) element

(d) atom (4)

1.4 The mass number of a certain atom is 234, and it has 60 % more neutrons than protons. Identify the atom in question. (4)

1.5 (a) Distinguish an empirical formula from a molecular formula. (2)

(b) Give two examples to support your answer in (a) (1)

(c) What is the percentage of sodium in Na_2SO_4? (4)

[25]

Question 2

2.1 (a) How does Arrhenius' description of an acid differ from that of Lowry-Bronsted? (2)

(b) What is the mathematical relationship between pH and pOH of a solution? (2)

2.2 Magnesium hydroxide, ($Mg(OH)_2$) is often used as medicine to relieve an upset stomach. The pH of HCl (aq) in a person's stomach is 1.

(a) Calculate the concentration of hydrochloric acid in the person's stomach. (4)

(b) Will the pH in the stomach increase, decrease or stay the same after taking a dose of $Mg(OH)_2$? (2)

(c) Write down a balanced equation for the reaction that takes place in the stomach after a person takes a dose of $Mg(OH)_2$ (4)

2.3 Use Lewis symbols to illustrate how barium reacts with nitrogen to form barium nitride. (5)

2.4 Name the following compounds:

(a) N_2O_5

(b) $Ca_3(PO_4)_2$

(c) Fe_2O_3 (3)

(d) What does the subscript numbers 2, 3 and 4 in $Ca_3(PO_4)_2$ represent? (3)

[25]

Question 3

3.1 The following readings were obtained in an experiment to determine the relationship between pressure and volume of a given gas at constant temperature.

Volume/ dm^3	250	275	300	325
Pressure/mmHg	700	800	900	1000

(a) Use one of the gas laws to comment on the reality of the results. (2)

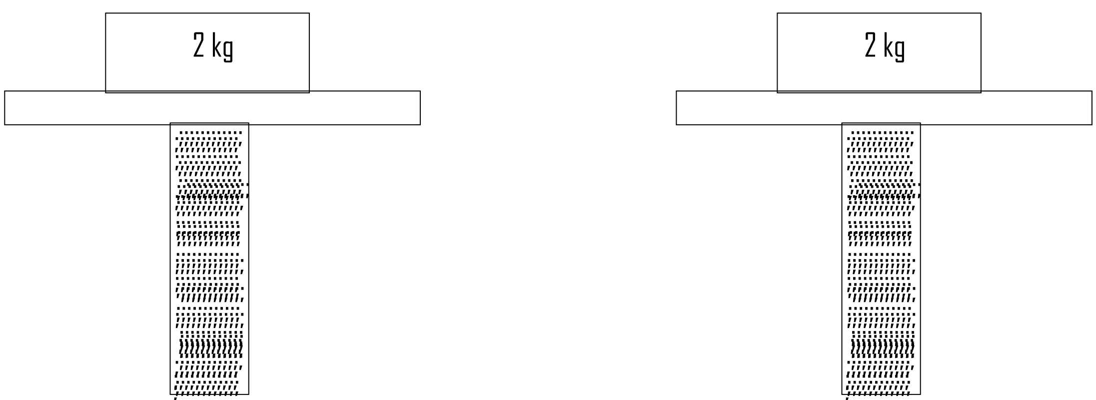
(b) What volume will 500 cm^3 of gas initially at 25 ^0C and 750 mmHg occupy when pressure changes to 650 mmHg while temperature remains constant? (3)

(c) Which law is applied in the above question? (1)

3.2 The following diagram represents two air-tight syringes with a 2 kg mass piece on top of each of the pistons. Both cylinders contain a mixture of N_2O_4 and NO_2 which has reached equilibrium. The colour of the gas mixture is light brown.

$$N_2O_4(g) \quad + \quad HEAT \quad \rightleftharpoons \quad 2NO_2(g)$$

Colourless   Reddish-brown



CYLINDER I   CYLINDER II

The following experiments are performed with the above gas mixtures:

Experiment 1: the 2 kg mass piece on cylinder I is replaced by a 1 kg mass piece

Observation: the colour of the gas mixture becomes darker after a while

Experiment 2: cylinder II is surrounded with ice.

Observation: the gas mixture becomes virtually colourless.

(a) Use the given reaction equation and *Le Chatelier's* principle to explain the above observations. (6)

3.3 Two girls each prepared hydrogen gas by adding dilute sulphuric acid to zinc granules. In both cases the gas is liberated at the same speed. However, when girl A, added a few pieces of copper to her reaction mixture, the reaction in her test tube proceeded noticeably faster. In both cases temperature increased as the reaction proceeded.

(a) what role does the copper play in this case? (1)

(b) which other three methods could girl B use to increase the rate of the reaction? (3)

(c) classify the reaction as endothermic or as exothermic and give a reason for your choice. (2)

3.4 Make use of an energy diagram to explain the effect of a catalyst on the rate of a chemical reaction. (draw and interpret this diagram) (7)

[25]

TOTAL = 75

Appendix G: Solutions for the Instrument to Assess Chemistry Learning Outcomes of First Year Medical Students

Question 1

1.1

(a) Pure substance is any matter with fixed composition and distinct proportions. (1)

(b) Solution is a homogeneous mixture. (1)

1.2

(a) Dilution. (1)

(b) $V_{\text{(saline to be taken)}} = 0.9\% \times 100 \text{ ml} / 10\%$
$= 9\text{ml}$ (1)

Take exactly 9.00 ml 10% saline solution, transfer it with a pippet into a 100 ml volumetric flask, and fill the flask with to the mark with water. (2)

(c) Dose for 85kg body weight = 85 kg x 0.04 ml / 1 kg (2)
= 3.4 ml (2)

1.3

(a) Atomic mass is the sum of protons and neutrons in the nucleus of an atom (1)

(b) Atomic number is the total number of protons in the nucleus of an atom (1)

(c) An element is a substance made up of group of atoms of the same kind. (1)

(d) An atom is the basic component of all materials (1)

1.4

Let the number of protons be x, (1)
Then number of neutrons = x + 0.6 x (1)
And mass number = x + x + 0.6x (1)
234 = 2.6x
i.e. x = 234 / 2.6
= 90
The element is therefore Thorium (Th) or element number 90 (1)

1.5

(a) In an empirical formular the proportions of each kind of atom in a molecule will be indicated, while in the molecular formular the actual number of each kind of atom will be indicated. (2)

(b) $C_6H_{12}O_6$ is the molecular formular of a substance while $CH_2O$is its empirical formular. (1)

(c) MW (Na_2SO_4) = 2 x Ar (Na) + Ar (S) + 4 x Ar (O)
= 2 (23 g / mol) + 32 g / mol + 4 (16 g / mol) (1)
= 46 g / mol + 32 g / mol + 64 g / mol
= 142 g / mol (1)
% Na = 46 g / mol ÷ 142 g / mol x 100% (1)
= 32.4% (1)

Question 2

2.1

(a) Lowry –Bronsted describe and acid in terms of its ability to transfer protons While Arrhenius describes an acid in terms of its ability to increase the concentration of protons when dissolved in water. (2)

(b) pH + pOH = 14 (2)

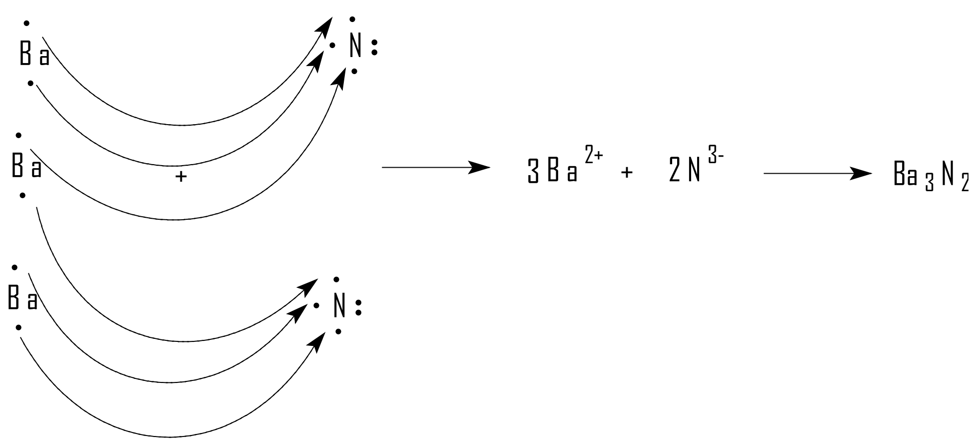
2.2

(a) (H+) = antilog (-1) (2)
= 1×10^{-1} (1)
= 0.1 (1)

(b) magnesium hydroxide is basic, its consumption will lower the acid content in the stomach, this will result in the decrease in pH level. (2)

(c) $2HCl + Mg(OH)_2 \longrightarrow MgCl_2 + 2H_2O$ (4)

2.3



2.4

(a) Dinitrogen pentoxide (1)

(b) Calcium phosphate (1)

(c) Iron III oxide (1)

(d) The numbers 2, and 3 represent the ratio of sulphate ions to the calcium ions in the molecule of calcium phosphate, while the number 4 represents the number of oxygens in the phosphate ion. (3)

Question 3

3.1

(a) From the table when volume of the gas is increased the pressure also increases, however Boyle`s law says the pressure of an enclosed gas is suppose to increase when volume is decreased. The results therefore could not be real. (2)

(b) V = 500 cm^3 x 750 mmHg ÷ 650 mmHg (1)
= 576.9 cm^3 (2)

(c) Boyle`s law (1)

3.2

(a) Replacing a 2 kg mass piece on the cylinder with a lighter mass piece will result in relieving the pressure of the gas inside the cylinder which will result in increased volume of the gas inside. According to Le Chatelier`s principle, increasing the volume of a gaseous equilibrium mixture causes the system to shift in the direction that increases the number of moles of gas. In this experiment that will be to the direction of nitrogen dioxide which is darker as compared to the other gas in the mixture. (3)

In experiment 2 the ice will lower the temperature of the reaction mixture and Since the given reaction is endothermic the lowering of the temperature according to Le Chartelier`s will make the equilibrium to shift to the direction that will produce heat which in this case the side of dinitrogen tetroxixe which is colourless. (3)

3.3

(a) Catalyst (1)

(b) Use concentrated sulphuric acid, grind zinc into powder or heat the reaction mixture (3)

(c) Exothermic, it was reported that temperature was released during the process. (2)

3.4

A catalyst usually lowers the overall activation energy for a reaction by providing a completely different mechanism for the reaction. In the diagram the catalyst has provided an alternative path for the reaction by lowering the activation energy. In this case the catalyzed path will react at a faster rate than the uncatalyzed reaction.