

# PROBLEMS FIRST-YEAR UNIVERSITY STUDENTS BRING TO SCIENCE CLASSES AND IMPLICATIONS FOR TEACHING AND LEARNING

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## ABSTRACT

An exploratory study was conducted to investigate firstly, the contextual problems first-year university students experienced at their respective schools and secondly, the subject related-problems that they could be bringing to science classes and which could later affect their understanding of science concepts. The study is grounded in constructivism. A questionnaire was administered to all the 2007 First-year B.Ed (FET) Natural Science students at the Central University of Technology, Free State. The contextual problems identified by respondents included school, educator, examiner and student-related problems. Subject specific problem areas were identified in biology, chemistry and physics. The paper also reports on the preliminary results of some teaching interventions implemented in the three subjects. A Force Concept Inventory (FCI) test was administered to the physics students, and a concept test for chemistry group. Concept mapping as a teaching and learning strategy has been introduced in biology classes. Further research continues on the effectiveness of these interventions.

**Key words:** Transition, Science Education, Constructivism, Prior learning, Concept development

## 1. INTRODUCTION

The B.Ed (FET) Natural Sciences programme is a four-year qualification that prepares teachers to teach mathematics, biology and physical science at the Further Education and Training band of the South African education system. Students choose at least two major subjects from a list of four, namely, mathematics, physics, chemistry and biology. Mathematics is compulsory at first year level since advanced mathematical computations are needed for solving problems in chemistry and physics at subsequent levels.

By introducing the programme the institution was responding to the national agenda of the South African government to intensify the preparation of mathematics and science teachers in order to alleviate the shortage of teachers in these so called "scarce skills" subjects.

In 2004 the programme started with 20 students and the enrolment increased gradually over the subsequent years. Lecturers in the programme observed that the students experienced problems regarding the understanding of certain concepts in biology, physics and chemistry.

In 2007 the researchers resolved to conduct a study to investigate the problems that the first year students experienced at high school which could influence their performance in these subjects at a tertiary level. The identified problem areas would then be used to develop some teaching and learning strategies that would help the students to have a better understanding of science concepts. This could also, to a certain extent, help to ease their transition from secondary to tertiary education science.

It is against this background that the following research questions were formulated to guide the study.

The study was guided by the following research questions:

- What problems do the first year students in the B.Ed (FET): Natural Science's programme bring to science classes?
- What are the causes of the problems?
- What teaching and learning strategies can be used to assist the students?

## **2. THEORETICAL PERSPECTIVES BASED ON THE LITERATURE REVIEW**

### **2.1 Problems in Science Education**

The transition from one phase of schooling to another (Brandsfort 2004) and from school to university (Green, 2005; Lowe, 2003; Smith, 2004; Burt & Mills, 2006) has been found to be problematic. The problems could occur due to the preparedness of the students for the particular phase or lack thereof, the teaching methods used and the content knowledge at the particular phase of learning (Smith, 2004). Green (2005) cites the following specific problems in learning English at first year university level: coming to terms with a new set of cognitive and metacognitive demands, teaching practices, study patterns, levels of independence, assumptions, expectations and assessment procedures. The same applies to science students.

Student preferences have also been found to present problems to the teaching and learning situation. Seymour and Hewitt (1997) argue that students have certain preferences and cite different learning styles, classroom climate and pedagogy as factors that create problems for students and which could even force them to abandon a career in science. Taking the argument further, Ford, Obiakar, and Patton (1995) argue that culture has an impact on the behaviour, learning styles and preferred teaching styles.

They go on to say that, in addition to teaching styles, issues of teachers' improper attitudes towards students of different cultural backgrounds, teachers' diverse cultural ineptness and differential behaviours towards students affect teaching and learning of science (Ford *et al*, 1995). This clearly shows that any transition is accompanied by diverse and complex problems and demands that serious attention be given to the experience of students moving into higher education from a variety of institutional as well as academic backgrounds.

Another problem is cultural border-crossing. The move by students from their everyday culture into the culture of school science is referred to as cultural border-crossing. For the vast majority of students whose home worldview differs from that of school science, cultural-border crossing is not smooth, as it may result in "collateral learning." Learning something in one cultural setting that conflicts with indigenous knowledge in a different cultural setting is called "collateral learning". Collateral learning was proposed by Jegede (1995) who used a rainbow to illustrate the concept. The scientific explanation of a rainbow, which is caused by refraction of light rays by droplets of water, is different from the explanation of rainbow as signifying a python crossing a river or the death of an important chief, as is the case in some cultural contexts. There are many such conflicts in the science classes, which originate from cultural beliefs and which have become accepted as true in some communities. For example, the scientific explanation for lightning differs from some African communities' understanding of lightning as being associated with witchcraft.

Science uses a particular language which is precise. This makes scientific language completely different from everyday language. Some non-science books, magazines and advertisements do present incorrect information about science concepts, which could be taken as correct by ordinary people. For example, fertilisers are often referred to as "plant food" and some drinks as "energy drinks". The concepts of speed and velocity have been used interchangeably and sometimes incorrectly. Such everyday language use which is not scientifically correct is called "common sense knowledge". Common sense knowledge is found in many science classrooms and affects learning. Teachers should, therefore, not overlook everyday language use as a learning tool (Stepanek, 2004).

Language deficiencies in explaining scientific concepts also affect the teaching and learning of science concepts. In IsiXhosa for example, there is only one word for energy (ability to do work), power (rate at which work is done), and masculinity, which is, "*amandla*". There is only one word for blue, green, and raw and that is "*iluhlaza*". There is one word for melting (change from a solid to liquid phase) and dissolving (solute dissolves in a solvent to form a solution) and that is "*ukunyibilika*". The list is endless. Such problems are easily observed in the science classrooms. Most students formulate their thoughts in their own language and then render a literal translation from their mother tongue into the language of instruction. This is called code switching. It is during this process of code switching that problems occur.

The medium of instruction, which is mainly English in South African schools, is also a problem. Research has shown that language proficiency is related to science content knowledge (Torres & Zeidler, 2002). For the majority of our students English is a second and even a third language. The same is true of science teachers.

From the foregoing exposition it is evident that science students bring to science classes different experiences, as they come from different backgrounds. Some of these experiences create problems for the learners as they influence their interpretation and understanding of science concepts in a negative way. It is therefore important for teachers to identify such problems as they will affect learners' understanding in later years. The same is true for first year entrants in the tertiary institutions (Potgieter, Rogan & Howie, 2005). First year entrants to tertiary institutions come from different schools, having been exposed to different school and life experiences. This progression could be a traumatic experience for students who are ill-prepared and have not been exposed to resources such as laboratories, library facilities and computers. The shortage of qualified teachers in mathematics, biology and physical science, lack of material and financial resources in the schools and the medium of instruction, either English or Afrikaans, also contribute to difficulties in mastering both the content knowledge and the conceptual understanding of these critical subjects.

Research has also shown that teachers' problems such as the inability to teach practically were underpinned by the teacher's lack of understanding of science concepts and processes (Mwangi-Zake, 2007). Teachers refrain from doing practical work not because there are no apparatus, but because they cannot do them partly because they themselves were never exposed to practical work.

The problems that have been exposed necessitate an in-depth study of the teaching and learning of science.

## **2.2 Teaching and Learning in Science**

Science teaching and learning appears to be rooted in constructivism. It is imperative at this stage to take a brief look at what constructivism entails.

### **2.2.1 Constructivism**

Constructivism is not a single, homogeneous theory of learning. The term is used to denote a cluster of related views (radical constructivism, social constructivism, sociocultural approaches, emancipatory constructivism, social constructionism) that rest on the assumption that learning is a process of constructing meaning derived from the learner's action in the world, or a process of knowledge construction (Gravett, 2006). Constructivists argue that learners are not passive beings that respond to "stimuli" and that learning is not a process of perceiving and recording ready-formed and pre-packaged knowledge that is stored in the brain to be retrieved later.

Learning is an active process of constructing meaning and transforming understanding in interaction with the environment. John Dewey is often cited as the philosophical founder of this approach, while Ausubel, Bruner and Piaget are considered the chief theorists among the cognitive constructionists, while Vygotsky is the major theorist among the social constructionists (Huitt, 2003). Activity theory and situated learning are traced to Vygotsky.

### 2.2.2 Constructivism, Cognitive Approach to Learning and Science Education

The contributions of Piaget, Vygotsky, Ausubel and other researchers have laid a foundation for many of the changes that have occurred in science education. Piaget's theory of cognitive development describes four levels of intellectual growth through which humans progress, namely: the sensori-motor; preoperational; concrete operational and formal operational stages (Mwamwenda, 2004). The final two stages are more applicable to secondary science teachers, as learners at this stage are expected to operate at these levels. Learners at the concrete operational stage have the ability to think logically and concretely about objects and events, while at the formal operational stage they have the ability to think more abstractly and hypothetically about complex concepts and ideas.

The implication of Piaget's research in science instruction is the idea that any given group of learners can display a wide variety of cognitive abilities which teachers should be aware of. Another contribution is his theory of cognitive structures and logical mathematical operations. This theory stresses the importance of learners developing their own internal structures as they learn. It also emphasises interactions with objects and events as learners attempt to construct their own understandings of scientific concepts. To accommodate these ideas into science instruction, teachers have to promote more concrete experiences in the classroom and encourage learners to search for meaning and relationships when confronted with apparently contradictory or difficult information.

Vygotsky's major contribution towards the cognitive approach to learning was his description of the influence of social interaction on cognitive development. He emphasised the learner's environment and the learner's interactions with other people through the use of language. He argued that, in order for cognitive development to occur, learners must receive information and guidance from others. Two important features of his research are private speech and the zone of proximal development. Private speech involves a learner's internal thought processes used to regulate problem-solving skills. The zone of proximal development describes the level between the teacher's knowledge and the learner's capabilities where instruction is most beneficial. These two work together when a teacher assists a learner to solve a problem by providing him or her with structure and encouragement and then gradually backing off to allow the learner to rely on his or her own private speech to complete the task.

The zone of proximal development underscores the important roles of peers and adults in promoting the construction of knowledge in the minds of students. The idea that learners rely on human interaction to construct their own knowledge has resulted in greater emphasis on cooperative learning activities that allow students to benefit from insight of others in order to acquire new concepts. Also, the realisation that social interaction as a vital part of learning has put less emphasis on student's personal discovery of scientific concepts and more emphasis on collaboration and interaction among learners of science <http://www.geocities.com/jjmohn/research.htm>.

### 2.2.3 Ausubel's Theory of Learning

Whereas Piaget and Vygotsky emphasise learner's personal construction of knowledge, Ausubel emphasises the importance of reception learning which is based on the idea that most of what is learned is acquired through the transmission of ideas and not through discovery. The learner's existing knowledge plays a very important role in the learning process as new learning builds on and is constructed through the learner's existing frames of reference. Ausubel (1968: 127-128) in Gravett (2005:20) argues that:

Existing cognitive structure...is the principal factor influencing meaningful learning and retention. Since logically meaningful material is always, and can only be, learned in relation to a previously learned background of relevant concepts, principles and information... it is evident that the substantive and organisational properties of this background crucially affect both the accuracy and the clarity of these emerging new meanings and their immediate and long-term retrievability.

In a later edition, Ausubel (1978) in Mwamwenda (2004: 194) says:

If I had to reduce all of educational psychology to just one principle, I would say this: the most important single factor influencing learning is what a learner already knows. Ascertain this and teach accordingly.

What the learner already knows, is the key factor to Ausubel's theory of learning. Within the context of science education Ausubel's theory plays a crucial role in understanding how learners receive and process content knowledge. He is concerned, for example, with how individuals learn large amounts of meaningful material from verbal or textual presentations in a school setting in contrast to theories developed in the context of laboratory experiments. He described learning in terms of the processes that occur during the reception of information (reception learning) and he differentiates between meaningful and rote learning. Meaningful learning occurs when new knowledge is consciously linked or incorporated into one's cognitive structures. Students should therefore relate new knowledge (concepts and propositions) to what they already know.

The latter is sometimes referred to as “prior learning”. The central point in Ausubel's theory is the idea of an “advance organiser” which is considered to be a way to help students link their ideas with new material or concepts. In other words, the function of an “advance organiser” is to bridge the gap between what the learner already knows and what he needs to know before he can successfully learn the task at hand (Mwamwenda, 2004: 196). When “advance organisers” are used they should be presented in a language that can be followed by learners as this will enable them to grasp the new material. Some aids that can be used as part of advance organisers are illustrations, pictures, comparison, contrast and verbal metaphors.

### 2.3 Teaching and Learning Strategies based on Constructivism

From the forgoing exposition it becomes evident that all the constructivist theories have a place in science education. Advocates of a constructivist approach suggest that educators first consider the knowledge and experiences students bring with them to the learning task. The curriculum should then be built so that students can expand and develop this knowledge and experience by connecting them to new information. The constructivist teachers pose questions and problems, then guide students to help them find their own answers. They use many techniques in the teaching process, for example, they may:

- prompt students to formulate their own questions (inquiry);
- allow multiple interpretations and expressions of learning (multiple intelligencies);
- encourage group work and the use of peers as resources (collaborative learning).

In a constructivist classroom, learning is constructed. Students are not blank slates upon which knowledge is imprinted. They come to learning situations with already formulated knowledge, ideas, and understandings. This existing or prior knowledge serves as the raw material for the new knowledge they will create.

They should therefore be presented with learning experiences that will make them think, reflect, collaborate, inquire and construct knowledge.  
[http://www.thirteen.org/edonline/concept2class/constructivism/index/\\_sub2.html](http://www.thirteen.org/edonline/concept2class/constructivism/index/_sub2.html).

This view is supported by other researchers who argue that classroom environments that incorporate constructivism and inquiry into their daily organisation can allow students the chance to “think scientifically (Polman, 2000) and to carry out investigations in a focussed, collaborative, and meaningful manner (Wilhelm, Thacker, & Wilhelm, 2007).

Also in support of teaching and learning strategies within the constructivist view of learning, Knipp (2001) has developed “Background knowledge surveys” comprising a series of short, simple questions, which can be used to disclose the breadth of the course material to students in a single setting and subsequently to summarise what the students have learned.

It can also be used to help teachers to determine the most appropriate level at which to begin instruction. They have been found to be useful in classes in which students have diverse backgrounds and knowledge levels and/or show varying levels of preparation.

Concept tests and concept maps are instructional strategies that are based on Ausubel's theory of learning which emphasises the importance of establishing the learner's existing knowledge as this forms the knowledge base on which new information can be built. Novak and Gowan (1984) developed a theory of instruction that is based on Ausubel's meaningful learning principles. Such a theory of instruction incorporates concept maps to represent meaningful relationships between concepts and propositions. A concept map is a kind of visual road map showing some of the pathways that could be taken to connect meanings of concepts. To be able to do that concept maps should be hierarchical, the more general, more inclusive concepts should be at the top of the map, and the more specific, less inclusive concepts at the bottom. It can be used to determine the nature of the students existing knowledge. It has been used extensively as a teaching and learning tool (Mwakapenda & Adler, 2002; Brussow 2005).

In contrast to radical constructivism which emphasise cognitive development social constructivism emphasises learning as a social activity. Social theories of learning view learning as a social and interactive process. It is through engaging and interacting with other learners that learning takes place.

The advantage of the constructivist view of learning, as was indicated earlier on, is the use of a variety of teaching and learning strategies. Learning is seen as an active process rather than a passive activity or event. While the study acknowledges the importance of relating new knowledge to existing knowledge and organising information in a meaningful way, it also acknowledges the social nature of learning. It thus becomes the lecturers' responsibility to find out what the students already know and then help them to make learning meaningful, by encouraging interaction between them.

### **3. RESEARCH METHODOLOGY**

This study has followed a qualitative literature study and an empirical investigation. It is a case study of the first year students enrolled in this particular programme in 2007. Welman and Kruger (2001:190) in White (2005) argue that a case study deals with a limited number of units of analysis, such as an individual, a group or an institution. Studying a group or an institution makes it possible for the problems to be studied in context.

Case studies can employ both qualitative and quantitative research methods and are used for different purposes.

This particular study was exploratory and descriptive in nature. Neuman (1997:20) lists the following as some of the goals of exploratory research: to “become familiar with the basic facts, people and concerns involved; determine the feasibility of doing additional research and to develop techniques and a sense of direction for future research.” The B.Ed (FET) Natural Sciences programme was therefore chosen for the study to investigate the problems students in the programme might be experiencing and which might affect their understanding of science concepts.

The population for the study comprised all the first year students enrolled in the programme in 2007. The student enrolment at the time of data collection was 41.

The questionnaire that was designed to collect data from the respondents contained both closed and open-ended questions. The biographical information on the questionnaire included: the name of the previous school the students attended; their gender and the symbols they obtained in biology and physical science at senior certificate level. The five open-ended questions in the questionnaire related to factors that contributed to the performance of the students in biology and physical science as well as the actual problem areas in the two subjects. These specific questions were made open-ended as the researchers needed to get the information from the respondents themselves in order to understand their problems. All 41 students answered the questionnaire.

## **4. FINDINGS**

### **4.1 Student Profile**

Of the 41 students who answered the questionnaire 17 (41.5 %) were male and 24 (58.5 %) were female students. 39 students came from 29 different schools in the Free State. Only three (3) came from outside the province.

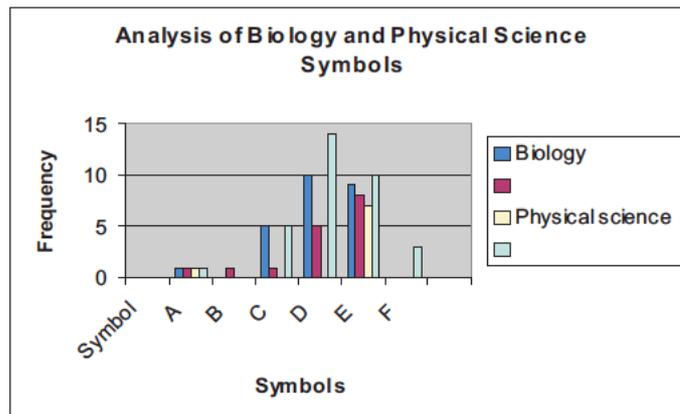
### **4.2 Analysis of Grade 12 Results**

As shown in Table 1, the majority of students, that is, 33 (80.5%) passed physical science on standard grade and only 8 (19.5%) passed the subject on higher grade. The performance was better in biology, as 25 (61%) passed biology on higher grade while 16 (39%) passed it on standard grade. Although mathematics did not form part of the study, it is important to note that the majority of the students passed mathematics on standard grade. In fact, according to the students, they were instructed by the schools to register for mathematics on standard grade.

**Table 1. Analysis of Biology and Physical Science Symbols**

Symbol	Biology		Physical science	
	n = 41		n = 41	
	HG	SG	HG	SG
A	1	1	1	1
B	-	1	-	-
C	5	1	-	5
D	10	5	-	14
E	9	8	7	10
F	-	-	-	3
Total	25	16	8	33
	61%	39%	19.5%	80.5%

The information is further shown in Figure 1.



**Figure 1. Analysis of Biology and Physical Science Symbols**

The analysis of the students' results revealed the following:

- Average to low performance of students in the two subjects, especially in physical science.
- Low level of content knowledge, as the majority of students registered for the two subjects on Standard Grade.

The next section looks into the factors that had contributed to the performance of students in the two subjects

### 4.3 Contextual Factors that Contributed to the Performance of Students in the Two Subjects

The contextual factors that were identified were grouped into three categories as follows:

Subject and teacher-related problems which included the following:

- Terminology (language used in science)
- Teaching methods used
- Too much work or overloaded syllabus (especially biology and chemistry)
- Lack of support from the educators
- Teacher Mobility
- Topics that were taught very late in the year
- Topics that were not taught at all
- Length of the question papers
- Questioning style of the examiners

School-related problems were:

- Lack of laboratory equipment
- Inability to do practical work
- Being confined to one textbook

Student-related problems were:

- Poor time management skills
- Inadequate preparation for the examination
- Staying far from school
- Problems with analysing the questions
- Negative attitude towards the subject (especially biology)
- Hatred for the subject (biology)

The students complained about the language used in teaching biology and physical science, teaching methods and styles, overloaded syllabuses, assessment and inability to do practical work. Some have even developed a negative attitude towards the subjects, especially biology and the chemistry part of physical science. The following excerpts prove the point:

*“I have got an attitude towards the subject (biology) and I am not enjoying it as well. There is too much work that does not make sense.”*

*“The language that they use in physical science is confusing. I prefer to do practical work.”*

*“I think my main problem was to familiarise myself with the terminology which is used, especially in Genetics.”*

*“In our school we had only one teacher for physical science and we did not understand him. I am a slow learner, it is difficult for me to understand questions in physics and be able to use the correct formulae.”*

*“Physical science was very difficult and there was a shortage of physical science teachers.”*

*“I have a problem in physics not in chemistry. To be specific, I do not know physics.”*

*“I misunderstood chemistry in physical science. I do not know how to balance equations.”*

A further discussion of these problems is found in the section on subject-specific problems.

Examiners also take the blame, as some students complained about the length of the question papers and questioning styles of the examiners. However, it is the responsibility of the teachers to familiarise the learners with the format and standard of the final examination papers. Regarding school factors, it should be noted that the problem of a lack of resources which makes it difficult for students to be exposed to practical work is not a new problem in South African schools. The question is, for how long should schools continue in this manner? Teacher mobility is also a cause for concern. Some students indicated that they had had three physical science teachers in one year and had to adjust to different teaching styles. The teaching style therefore affects the performance of learners at school.

The lack of support from teachers is a serious problem and needs further investigation as it could lead to more students developing a negative attitude towards the subject and eventually affecting the overall performance of the student in that particular subject in subsequent years. Having looked at contextual factors, it is now imperative to focus on subject specific problems.

#### 4.4 Subject specific Problem Areas

The breakdown of the problem areas in biology is shown in Table 2.

**Table 2. Problem Areas in Biology (n =41)**

Topic	Frequency %	age
Population dynamics	10	24.4
Plant water relations	10	24.4
Homeostasis	9	22.0
Nervous co-ordination	9	22.0
Chemical co-ordination	4	9.8
Cellular respiration	6	14.6
Photosynthesis	3	7.3
Biological compounds	5	12.2
Digestive system	4	9.8
Excretion	3	7.3

Population dynamics and plant water relations ranked high as the areas which pose problems to the students, followed by homeostasis and nervous co-ordination. The reasons cited included information overload and the fact that these topics were taught at the end of the year shortly before the examinations and in some instances, during the examinations. Why were they taught very late in the year? Is it because teachers themselves are not competent in handling these sections? This needs further investigation.

Problems that were identified in physical science have been categorised into chemistry and physics. Table 3 shows the breakdown of the problem areas related to chemistry.

**Table 3. Problem Areas in Chemistry (n = 41)**

Topic	Frequency %	age
Chemical equilibrium	10	24.4
Organic chemistry	10	24.4
Acids and bases	6	14.6
Redox reactions	4	9.8
Rate of reactions	2	4.9
Periodic table	4	9.8

Chemistry was identified as the most difficult section of physical science. The students complained that some educators concentrated on physics and ignored chemistry. While respondents identified specific topics some remarked:

*“the whole of chemistry is a problem” or “Paper 2 is a problem.”*

Amongst the specific areas identified, chemical equilibrium and organic chemistry ranked high, followed by Acids and Bases. These sections are interrelated and a problem in one could lead to problems in the other.

Non-availability of laboratories and laboratory equipment in the schools made it difficult for the teachers and students to perform experiments. Tertiary institutions are expected to build on the senior certificate syllabus in both theoretical and practical knowledge. In such instances, the anchoring concepts that are supposed to lay a foundation on which to build or construct new knowledge are non-existent. Lecturers, therefore, should not assume that the students possess the requisite knowledge in these subjects. They should find out about the learners existing knowledge in the subject and then proceed from there. The anchoring concepts are, therefore, very important as subsequent knowledge builds on them.

Organic chemistry was identified as a problem area. Organic chemistry is a broad area of the chemistry syllabus at tertiary level. Since it has been identified as a problem area at high school level, one needs to probe further to uncover the specific problems.

The next section deals with physics-related problems. Table 4 shows the breakdown of problem areas in physics

**Table 4. Problem areas in physics (n = 41)**

Topic	Frequency	%	age
Electricity	12		29.2
Mechanics	22		53.7
• Vectors and scalars			
• Equations of motion	13		31.7
• Momentum	5		12.2
	4		9.8

The students indicated that they preferred physics to chemistry. However they also pointed out that mechanics, especially construction of vector diagrams and resolution of vectors gave them a tough time. Electricity was also identified as a problem area.

## 5. INTERVENTIONS

As the first intervention concept tests were used in chemistry and physics. In physics a Force Concept Inventory (FCI) was used to assess students' understanding of concepts in Mechanics, since this section was identified as a problem area. The FCI is a 30-item multiple choice test for assessing student understanding of Newton's Laws of Motion. An adaptation to the multiple choice questions was made by adding an open-ended question which requested students to explain why they decided on a particular answer. This was done to eliminate the possibilities of arriving at the correct answer through guessing. The preliminary results of the test indicated the following:

- Some students use common sense knowledge to explain concepts in Newtonian mechanics.
- Common sense knowledge affects students' understanding of physics concepts.
- Common sense knowledge clashes with scientific knowledge and can lead to confusion and misconceptions on the understanding of concepts in mechanics.
- Lack of exposure to practical work at secondary school affect students' understanding of concepts in mechanics.

The results sensitised the lecturer to the problems students experienced in this section and helped him to vary his teaching methods. This is the practice that we intend to continue with regarding every new intake of students. The use of concept tests was also supplemented by group discussions and it is through this active engagement of students that more problems were identified. Research in this area continues.

In chemistry, a follow-up questionnaire was administered to identify specific problem areas in chemical equilibrium. Problems identified included application of Le Chatelier's principle, understanding the concept of dynamic equilibrium and the common ion effect. Based on the problems that were identified, a Chemical Concepts Inventory test was administered. The test consisted of multiple choice questions with the added part of requesting students to explain why they decided on the right answer. Analysis of the results of the test is still underway.

In biology the students have been exposed to concept mapping as a teaching strategy. While this is a good strategy to assess students' understanding of concepts, at the moment students are still learning the strategy and once they have mastered it, it is then that the researchers can be in a position to assess its effectiveness.

## **6. CONCLUSION**

The study has shown that students entering tertiary institutions bring with them problems that they have inherited from their respective high school. It has also shown that science classes consist of students who come from diverse backgrounds and knowledge levels and show varying levels of preparation. All these factors have been found to have an impact on learning. Teachers and lecturers should be aware of such problems and should consequently expose students to teaching and learning activities that will equip them with the skills to discover the problems, understand and accept that problems do exist, but that they could be overcome.

A variety of teaching strategies which take into consideration learners' prior knowledge, such as concept tests and concept maps could be used to identify the problems and help students to see the relationships that exist amongst concepts in a particular subject. Practical investigations, simulations and class discussions where learners are actively engaged could also help.

Use of a variety of teaching strategies might help to ease the transition from secondary to university physics, chemistry and biology.

## 7. REFERENCES

Brandsfort, J.D. 2004. How people learn: brain, mind, experience, and school. Expanded Edition. National Research Council

Brussow, S.M. 2005. Concept mapping: an invitation to creative thought. *Journal for New Generation Sciences*, 3 (2): 28-36.

Burt, R. and Mills, J. 2006. Taking the Plunge: The hopes and fears of students as they begin Music College. *British Journal of Music Education*, Cambridge: University Press.

*Constructivism as a Paradigm for Teaching and Learning: Concept to Classroom*. [online] Available from:  
<[http://www.thirteen.org/edonline/concepttoclass/constructivism/index\\_sub6.html](http://www.thirteen.org/edonline/concepttoclass/constructivism/index_sub6.html)>. Accessed 13 October 2007.

Ford, B.A., Obiakar, F.E. & Patton, J.M. 1995. *Effective Education of African American Exceptional Learners- New Perspectives* [online] Available from: <<http://www.as.wvu.edu/~equity/african.html>> [Accessed 14 August 2007]

Gravett, S. 2005. *Adult Learning: Designing and implementing learning events: A dialogic approach*. 2<sup>nd</sup> Ed. Pretoria: Van Schaik Publishers.

Huitt, W. 2003. Constructivism. *Educational Psychology Interactive*. Valdosta, GA: Valdosta State University. [Online]. Available from:  
<<http://chiron.valdosta.edu/whuitt/col/cogsys/construct.html>> [Accessed 13 October 2007]

Jegede, O.J. 1995. Collateral learning and the eco-cultural paradigm in science and mathematics education in Africa. *Studies in Science Education*, 25: 97-137.

Knipp, D. 2001. *Knowledge Surveys: What do students bring to and take from a class?* [Online] Available from:  
<<http://www.isu.edu/ctl/facultydev/KnowSfiles?KnippUSAFA/KSKNIPPUSAFA.html>> [Accessed 20 August 2007]

Lowe, H. 2003. Mind the Gap: are students prepared for higher education? *Arts and Humanities in Higher Education*. 3 (1): 81-93. February, 2004

Muwanga-Zake, J.W.F. 2007. *Is Science Education in a crisis? Some of the problems in South Africa*. [Online]. Available from: <<http://www.science in Africa.co.za/scicrisis.htm>> [Accessed 20 August 2007]

Mwakapenda, W. & Adler, J. 2003. Using concept mapping to explore student understanding and experiences of school mathematics. *African Journal of Research in Mathematics, Science and Technology Education*. 7: 51-62.

Mwamwenda, T.S. 2004. *Educational Psychology: An African Perspective*. Third Ed. Sandton: Heinemann.

Neuman, W.L. 1997. *Social Research Methods: Qualitative and Quantitative Approaches*. Boston: Allyn and Bacon.

Polman, J. 2000. *Designing Project-based Science: Connecting Learners Through Guided Inquiry*. New York, NY: Teachers College Press.

Potgieter, M., Rogan, J.M., & Howie, S. 2005. Chemical concepts inventory of Grade 12 learners and UP Foundation year students. *African Journal of Research in Mathematics, Science and Technology Education*. 9 (2).

Research and Current Efforts to Restructure Science Teaching [Online]: Available from: <<http://www.geocities.com/jjmohn/research.htm>> [Accessed 13 October 2007]

Smith, K. 2004. School to university: An investigation into the Experience of First-Year students of English at British Universities. *Arts and Humanities in Higher Education*. 3(1): 81-93. Feb.

Stepanek, S.J. 2004. *From Barriers to Bridges: Diverse Languages in Mathematics and Science*. Available from: <<http://www.nwrel.org/msec/nwteacher/winter2004/barriers.html>> [Accessed 20 August 2007]

Torres, H.N., & Zeidler, D.L. 2002. The effects of English language proficiency and scientific reasoning skills on the acquisition of science content knowledge by Hispanic English language learners and native English language speaking students. *Electronic Journal of Science Education*. [Online] 6(3) Available from: <<http://unr.edu/homepage/crowther/ejse/torreszeidler.pdf>> [Accessed 18 August 2007]

Wilhelm, J., Thacker, B. & Wilhelm, R. 2007. Creating Constructivist Physics for Introductory University Classes. *Electronic Journal of Science Education*. Vol.11, No. 2. <http://ejse.southwestern.edu>. [Accessed 20 August 2007]

White, C.J. 2005. *Research: A practical guide*. Pretoria: Ithuthuko Investments.