Factors contributing to poor performance of first year chemistry students

Fiona Marais and Andile Mji
Tshwane University of Technology
South Africa

1. Introduction

Many first year chemistry students in South Africa present an inadequate knowledge of the fundamental principles which underpin the study of chemistry. Ongoing studies at Tshwane University of Technology (TUT) indicate that this is a problem that emanates from the students' secondary education. The roots of the problem stem from the fact that many high schools often have inadequate resources. Also compounding the problem is a shortage of skilled teachers in mathematics and science at schools in the country.The research findings which will be discussed in this chapter are primarily focused on the problems students experience with stoichiometric calculations. A brief summary into science related misconceptions held by the students concerning physical and chemical change, with respect to conservation of matter is included since these initial research findings led to further investigation of the stoichiometry problem. In accordance with other researchers e.g. Fetherstonhaugh and Treagust (1992), prior learning was identified as a precursor to the misconceptions, which in this case included the underlying fundamental concepts on which chemistry is based.

2. The current learning environment

It is an unfortunate reality in South Africa that past imbalances in the education system continue to perpetuate poorly resourced schools and inadequately skilled teachers, particularly in the fields of mathematics and science (Ramose, 2003; Park, 2003). In addition to this the new government has embarked upon complete transformatory change to the entire education system. Outcomes-based education has been forced from the top down and teachers were unprepared for the enormity of the changes. The new system is resource demanding so the problems are exacerbated in resource disadvantaged schools. Many more students entering university have been able to attend better schools, but still there are many students who come from rural areas and townships where the schools remain over-crowded and poorly resourced. All the changes currently occurring in the school sector of the education system contribute towards the problem of poor preparedness for tertiary studies. This relates to students' study methods and the required self-discipline to attend all lectures and tutorial sessions. The lack of self-discipline is particularly noticeable when students are required to complete self-study assignments (Marais & Louw, 2008).

South Africa currently has a shortage of skilled artisans and university graduates. The government has relaxed the university entrance requirements in an attempt to increase the number of university graduates. Unfortunately, inadequate school systems result in poorly prepared students entering universities and in order to ensure that such students achieve success; special programmes have been introduced to overcome the problem. Some universities have started "Extended" programmes which allow students to complete the first year of study over a two year period while others, such as TUT, have used a "Foundation" programme, which allows six months preparation before starting first year courses. This preparation course typically includes classes in communication skills and writing skills as well as mathematics, physics and chemistry classes (Botha & Celliers, 1999; Kilfoil, 1999). Understanding, that point when knowledge can be successfully applied to different circumstances, cannot take place when there is no link to existing knowledge (Bennett, 2005). A Foundation programme offers the opportunity of ensuring that basic skills and knowledge are firmly embedded before the student starts the first year course. The underlying reasoning behind this is that the brain filters all new knowledge and links it with existing knowledge. When there is no link to existing knowledge the information will confuse the individual and fail to be retained. The working space inside the brain receives the events, observations and instructions from the immediate environs and proceeds to interpret, then rearrange and compare them according to what already exists in the cognitive memory (Bennett, 2005). Piagét described this process using the terms assimilation, accommodation and equilibration (Huitt & Hummel 2003). An individual's previous experience and environmental background will influence both the interpretation and the retention of the terminology. Should the information oppose existing concepts conflict may arise and the new information may be rejected until a link can be found to the new knowledge (Bennett, 2005). Other researchers have found that many students, unable to connect their existing knowledge with what is presented at university, often resort to memorising formulae, which helps answer algorithmic problems but does not ensure adequate knowledge, or understanding, of the fundamental underlying concepts involved (Gabel & Bunce, 1994). This limited solution, which may suffice for lower order learning (memorization and recall), must be overcome before any significant higher order learning (application of knowledge to different conditions) can take place.

3. Theoretical Background

Science is based on what can be seen, heard or touched rather than on personal or emotive opinions, but, if the existing knowledge used to describe observations is incomplete, or indeed incorrect, the ideas in the brain as well as the understanding of the experience observed will be defective (Chalmers, 1999). The concepts learners have generated while growing up, and particularly, the manner in which these were explained during formal tuition, represent the knowledge which has been acceptable and understandable to the individual. This represents deeply embedded learning, which cannot be ignored, but which must be correctly re-structured before misconceptions can be overcome. Overcoming misconceptions is not an instant process. In relation to this it has been reported that misconceptions of fundamental scientific principles are highly resistant to change (Brosnan

& Reynolds, 2007; Fetherstonhaugh & Treagust, 1992; Gabel & Bunce, 1994; Mulford & Robinson, 2002; Potgieter et al. 2007; Scalise et al. 2003). Similar findings concerning the difficulty of overcoming embedded misconceptions about chemistry concepts have already been reported and form part of the ongoing studies at TUT (Marais & Gummow, 2007).

Learning and growth of understanding involves the construction of existing knowledge with some part of formal teaching. Actual learning must involve some form of change to existing concepts before it can be accommodated in the brain as a broadening, or deepening of existing understanding (Bennett, 2005). When existing concepts do not agree with information presented during lectures the new knowledge may be interpreted and assimilated in one of two ways. First, the student may reject the new information outright because it does not make sense. Second the new information may be incorrectly assimilated to what exists in the student's knowledge base. In the former situation a student will generally indicate how they disagree with or do not understand the new information. The latter meanwhile gives rise to most of a student's misconceptions. Such misconceptions while based on a wrong knowledge foundation become conceptions that are ingrained and believed in the student's mind. This is what later results in the resistance of any attempt to change a student's understanding. Such misconceptions, because they are based on a misunderstanding of facts, have the added disadvantage of hampering higher order learning skills and problem solving skills. In order to enable conceptual change some means of confrontation with existing knowledge must be initiated (Tao & Gunstone, 1999). The confrontation entails convincing a student that their understanding of a particular concept is either incomplete or incorrect. More than this, the new information must be shown to be credible and valid in all instances of its application.

It has been reported that some students ignore the conflicting information and retain prior conceptions, while some although appearing to accept the information and adapt their prior conception, often remain unable to apply this any further than the particular context in which it was presented (Tao & Gunstone, 1999). Research into students' inadequate existing scientific concepts has been the focus of many researchers for decades and although all intervention techniques have achieved some level of success, none have overcome the problem (Hewson & Hewson, 1984). To demonstrate the difficulty in overcoming such conflict by means of traditional teaching methods, Hewson and Hewson (1984), cite research spanning over 70 years, of others in the field whose aim was to solve this particular problem. The studies were conducted by several researchers amongst whom Dewey (1910); Festinger (1957); Piagèt (1964); Berlyne (1965) and Nussbaum & Novick (1982) are examples.

A number of intervention methods, especially those using computers, have been implemented recently. Computer graphic representations and simulations together with PowerPoint presentations provide a useful teaching tool and greatly enhance the teaching situation. However, in some instances such tools are equally unable to overcome conceptual conflict. They remain, at best, a means to facilitate better understanding of three dimensional structures and rotations as well as retaining student interest longer (Clark, 1994). Structured worksheets have been developed by other researchers (Mulford & Robinson, 2002; Yitbarak, 2006) as a method of confronting this difficulty in an attempt to overcome the problem. A mixed method approach incorporating PowerPoint presentation together with structured worksheets, the use of tactile models, self-study assignments and targeted interviews is discussed in this chapter. In light of the work of other researchers the most appropriate means to overcome deeply embedded incorrect conceptions is one which creates conflict (Hewson & Hewson, 1984; Williams & Tolmie, 2000; Trumper & Gorsky, 1993). When students are required to produce their own graphic representations they should notice the conflict between these and the two dimensional diagrammatic representations as well as the 'Lego' blocks. It is contended that this situation will create the most favorable environment to identify the inherent causes of resistance to change and facilitate their remediation.

4. Background to the study

Understanding of physical and chemical properties and the changes which occur at both molecular and atomic levels is fundamental to understanding how matter is conserved and the manner in which this is related to the mass as well as number and type of atoms involved. Stoichiometric calculations involve chemical reactions in which reactants combine in simple whole number ratios and without fully understanding the fundamental concepts of matter conservation it will be difficult to balance chemical equations, determine percentage composition, have any idea how to determine a limiting reagent, or complete calculations which require understanding of how matter is constructed. Since all of these calculations are central to chemistry itself, it is vital that students hoping to graduate have not only fully understood, but have in fact mastered, these underlying concepts. The comparative results of the pre- and post- testing of the 2007 experimental group of students are discussed in detail in a separate article (Marais & Gummow, 2007). The results of pre- and post-testing of the 2008 student cohort is reported in a further separate article (Marais & Combrinck, 2009). The choice of a PowerPoint and computer-assisted intervention was made deliberately in order to sustain additional interest amongst the students. As part of the initial research, during a Pilot Study in 2007, students completed a qualitative assessment of both the PowerPoint presentation and the accompanying self-study CD. The findings of this assessment confirmed the acceptability of this approach, in spite of the majority of students taking part in this study not having their own computers and the university being inadequately resourced. A summary of the results of this assessment is included in this chapter.

5. The need for this study

After development and implementation of a computer-assisted intervention, which was purposefully designed to overcome identified difficulties first year chemistry students experience (Marais & Gummow, 2007) the level of improvement in some areas was unsatisfactory. Integrated worksheets were then developed in an attempt to address these areas more thoroughly (Gummow, 2007). The implementation and outcomes of these worksheets has already been reported (Marais & Gummow, 2007; Marais & Combrinck, 2009) and the initial findings of further worksheets, use of tactile models and students own graphic illustrations of stoichiometric calculations will be examined in this chapter. The results and discussion of this work will be of value to all tertiary institutions involved with the teaching of first year chemistry.

6. Conceptual framework

The high drop–out rate of first year entry level students at tertiary institutions is directly related to their inability to achieve understanding of the required knowledge. This problem is not unique to universities in South Africa or to TUT in particular (Fraser & Killen, 2003). High motivation and engagement in learning have consistently been linked to reduced dropout rates and increased levels of student success (Woods, 1995; Blank, 1997; Dev, 1997; Kushman et al. 2000; Fraser & Killen, 2003), as cited in (Marais & Louw, 2008).

Student motivation is often divided into two categories:

Extrinsic motivation: A student can be described as extrinsically motivated when he or she engages in learning simply to attain a reward or to avoid punishment (Dev, 1997).

Intrinsic motivation: A student can be described as intrinsically motivated when he or she is motivated from within being actively engaged in learning out of curiosity, interest, or enjoyment, in order to achieve their own intellectual and personal goals (Dev, 1997).

Developmental factors and students' perceptions about their own abilities also contribute towards their level of engagement in learning. The older students get, the less likely they are to take risks and engage themselves fully in activities at which they are not sure they will succeed. It has been reported that young children often remain optimistic of their abilities even when they have been unsuccessful, but older students are more realistic and are more hesitant to continue in the face of failure (Dev, 1997). Students whose self-concept is bound up in their history of failure are less likely to be motivated to learn than those who simply attribute poor performance to lack of attainable skills (Dev, 1997; Marais & Louw, 2008).

The proposed model which follows in Figure 1 is based on previously published work by the same researcher (Marais, 2008), and is a suitable summation of the current research problem presenting an appropriate starting point for solving the problems 1st year entry level students' face when studying chemistry. This model is relevant to all first year chemistry students irrespective of the particular course they have been accepted to study.

The framework, in Figure 1, illustrates how the educational background of each student is intertwined with socio-economic and community heritage which influences the acquired learning of each individual. When prior learning has been inadequate the result will be a high drop-out rate, unless the curriculum process can intervene in a manner which allows active interaction between students, lecturers and knowledge. Achievement of instructional outcomes depends on the success of the type of instructional intervention.

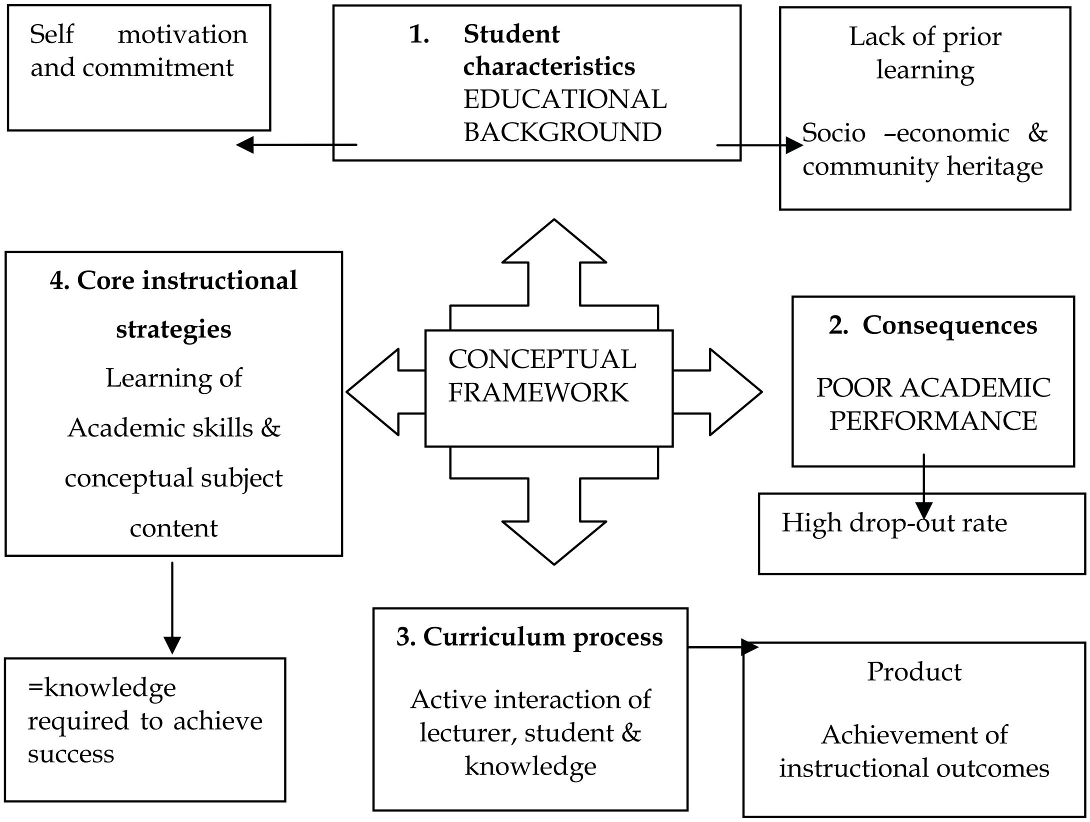


Fig. 1. Framework illustrating the inter-related facets which represent the learning environment of the typical first year chemistry student

Mastering of academic skills and conceptual subject content, which represent the knowledge required to achieve success, depend on the success of the interaction between lecturer, student and knowledge. This chapter is focused on the use of worksheets, tactile models, students own graphic interpretations of stoichiometric calculations and the symbolic language chemists use to represent these.

7. Research Methodology

This study was done using Action Research (AR) as a methodology. AR is a dynamic and integrated process where a problem is identified, a plan or intervention is proposed by a group of involved parties and the plans are then continuously applied, observed and interactively reflected upon. The plan is then to overcome both the originally envisaged problem and new extensions which develop as a direct result of the intervention. The advantage of such an approach is that it is neither limited to individualistic design, nor to rigid inflexible design (Dev, 1997). This process allowed continuous change and constant reflection and adaptation to changing circumstances and conditions. It is ideally suited to the times we live in where technological advances allow constant and ongoing improvement to all realms of instructional methodology. The additional purpose for this ongoing project is to allow for new ideas and adaptations to be made, until the required improvement is achieved. It is a process which could be applied to a broader spectrum of lecturers experiencing similar problems and would allow the findings to be continuously adapted in order to overcome the restraints of time and change as well as allowing adaptation to new ideas and technology.

8. Data collection tools

A standardised questionnaire, Mulford's Chemistry Concepts Test [MCCT] (Mulford & Robinson, 2002), was used as baseline assessment to identify possible misconceptions. The first application of MCCT was during the initial Pilot Study of 2007 as both pre- and post-test. The level of fundamental science knowledge the students presented on entry to the university was measured. Upon completion of the course the same test was used to ascertain whether their understanding had changed at all during the normal course of tuition. The computer-assisted intervention was designed in accordance with these results. The next cycle involved the development of structured work sheets as a further attempt to remediate misconceptions in the basic science knowledge of the students. (Gummow, 2007). The worksheets were used in conjunction with coloured building blocks which the students could use to help them envisage the breaking and reforming of chemical bonds between molecules. It was hoped that in this way the concepts would be more readily understood. The students were tested again after completing the worksheets with questions similar to those used in the standardised test instrument, (MCCT), to assess the level of success. The improvement was so marked that the worksheets used together with 'Lego' blocks was incorporated into the 2009 first year chemistry course as part of the introductory lecture presented after the pre-test but before commencement of formal lectures.

An adaptation of the standardised test, (MCCT), which used only 14 of the 22 questions, was applied to 326 first year chemistry students who registered at TUT in January 2009. This adaptation was made because not all of the original 22 questions were addressed in the computer-assisted intervention. A random selection of the 2009 students was required to draw their own graphic representation of the answer to a problem on stoichiometry. These students did not have access to the 5 distracters included in the multiple choice version of the same question. The disappointing results of this investigation led to the development of further worksheets by the corresponding author. These were completed by 174 of the 2009 students. The results of these worksheets are included in this chapter.

9. Results

9.1 Initial testing

The initial test results revealed that the 2009 intake had virtually the same levels of misconceptions as the cohorts of 2007 and 2008, according to their pre-test results. Similar results, pinpointing the same misconceptions, have been reported by other researchers in the field (Mulford & Robinson, 2002; Potgieter, et al. 2007). The Power-Point presentation and accompanying CD which was developed in 2007 and refined in 2008 has, due to the positive attitude of the students, been incorporated into the first year chemistry course. Results of this qualitative assessment of the computer-assisted lecture presentation are recorded in Table 1. Two groups of students were involved with these preliminary results, one group comprised 33 students in total and a further 20 students were randomly selected from a second group of 108 students The CD contains a review of the lesson material and some useful additional website links and quizzes. The CD was designed to be used as an additional self-study resource.

Topic	PowerPoint presentation	Accompanying CD
Arrangement was logical	85%	89%
The content was interesting	90%	91%
Attention was maintained	80%	94%
Will be useful to studies	90%	88%

Table 1. Qualitative assessment of initial computer-assisted intervention.

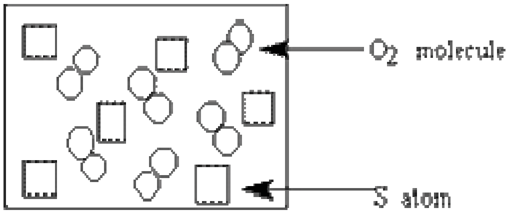
Both the presentation and the CD were evaluated according to logical arrangement, interest, ability to maintain attention and usefulness to studies.
In spite of only 26% of these students having their own computers, of whom only 10% had off-campus internet access, the overwhelming majority of students displayed a positive attitude towards computer-assisted learning.

9.2 Pre-test results of 2009

The 2009 pre-test results of 326 first year chemistry students record an average test score of 4/14, or 29%. The question concerning stoichiometry recorded the lowest scores and only 8% of the students identified the correct distracter. This question is taken directly from the chemical concepts test, MCCT, (Mulford & Robinson, 2002) and shown in Figure 2.

The diagram shows a mixture of S atoms and O_2 molecules in a closed container.

STARTING MIXTURE



Which diagram shows the results after the mixture reacts as completely as possible according to the equation: $2S + 3O_2 \rightarrow 2SO_3$

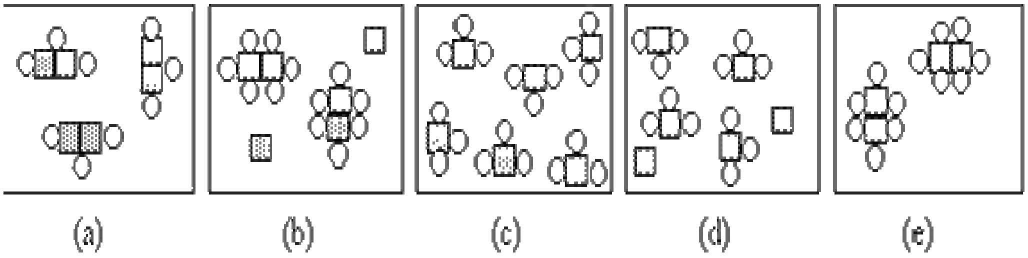
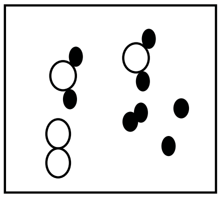


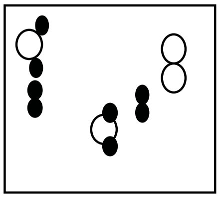
Fig. 2. The initial stoichiometry question showing five distracters

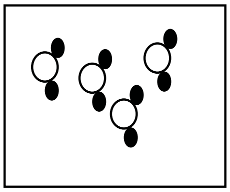
The majority of students selected distracter (e) and the few who realized that there was an excess of sulphur selected distracter (b). In light of the apparent confusion with subscripts and coefficients 62 students were randomly selected to draw a representation of what they believed the answer should be. These students only had the question and not the distracters in front of them. 68% of these students drew S_2O_6, 19 of them drew just two molecules, 16 drew only one molecule and six students indicated that there were two excess sulphur atoms. 16% of the students drew S_2O_3, but only two of them indicated that there would be three oxygen atoms in excess. 16% gave the correct representation of SO_3, but only two of them had the correct number of molecules and indicated the excess sulphur atoms. These results show that 82% of the students show some confusion between coefficients and subscripts in chemical equations. In addition 66% had no apparent concept of either limiting or excess reagents.

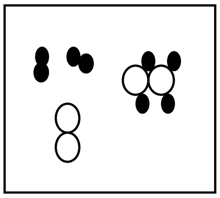
9.3 Results of the additional worksheets

Results of pre- and post-testing in both 2007 and 2008 indicated that the interactive worksheets used together with 'Lego' blocks helped the students to understand and accept the more resistant concepts associated with stoichiometric calculations. These worksheets were then incorporated into the introductory lectures for 2009. After commencement of formal lectures the first additional worksheets were applied to 174 of the first year chemistry students. This represents the group of students who were admitted to the 'Foundation Chemistry' programme. The first of these worksheets used a question based on the reaction of hydrogen gas and oxygen gas combining to form water (**$2H_2 + O_2 \rightarrow 2H_2O$**). The percentage of students selecting each of the distracters is shown – option (c) being correct. The level of difficulty was lower than that of the initial test question since there was no limiting or excess reagent. Exactly two molecules of oxygen and four of hydrogen were given as starting material. The balanced reaction equation was provided. The students had already worked with the 'Lego' blocks and it was believed that the improved results, only 8% correct on the pre-test and 58% on this worksheet, could also be attributed to this and not merely the level of difficulty.


(a)
(5%)

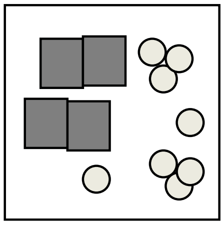

(b)
(6%)

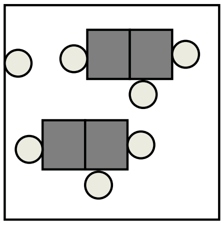

(c)
(58%)

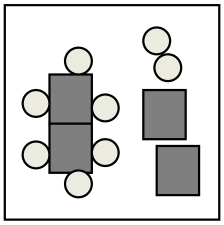

(d)
(31%)

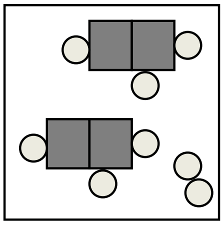
The other question on this worksheet required students to draw their own representations of the reaction between sodium and chlorine gas to form sodium chloride [$2Na(s) + Cl_2(g) \rightarrow 2\,NaCl(s)$] given 5 sodium atoms and 2 molecules of chlorine as starting materials. The correct product was noted by 21% of the students, but two thirds of these either used too few or too many reagents. 44% of the students gave the product as Na_2Cl_2 with only 17% of these using all reagents and correctly indicating excess. 18% gave $NaCl_2$ as the product and 13% simply joined all the reagents together in different ways showing no concept of reagent quantity. The remaining students, 4% simply wrote down the reagents unchanged, indicating that no reaction had taken place.

A second additional worksheet was then applied. The first question allowed students to select the answer from given representations and the second question required them to draw their own diagrams. Students were given four aluminium atoms and four molecules of chlorine with which to form aluminium chloride. The balanced reaction was given, $4Al(s) + 3Cl_2(g) \rightarrow 2Al_2Cl_3$. Option (d) is correct.


(a)
0%


(b)
25%


(c)
11%


(d)
64%

The second question in this worksheet was exactly the same as used in the initial test, and illustrated in Figure 2, but no possible distracters were given and students were required to draw their own graphic representation of the products which would form if six atoms of sulphur and six molecules of oxygen gas were allowed to react as completely as possible according to the balanced reaction $2S + 3O_2 \rightarrow 2SO_3$.

Answers were translated from the graphic form and recorded as indicated:

				correct option ↓	
$[2S_2O_6 + 2S]$	$[3S_2O_3 + 3O]$	$[2SO_3]$	$[2SO_3 + 4S + 3O_2]$	**$[4SO_3 + 2S]$**	$[2S_2O_6]$
22%	11%	7%	29%	9%	10%

$[S_2O_6 + 4S + 3O_2]$	$6SO_2$	incomprehensible
5%	2%	5%

More worksheets will be developed during the course of the current semester, but results of these and any post assessment analysis will be published at a later stage.

9.4 Results of focus group interviews

The results of focus group interviews conducted during 2008 indicate that other factors may influence the success rate of first year chemistry students. More interviews will be conducted with the current student cohort. The focus group interviews elicit qualitative data that support findings from other studies about the lack of student progress. There were two main themes that crystallised from the data, namely class room management and student characteristics.

Students expressed the fact that they needed to be motivated by the lecturer and also needed recognition for their attempts. Students expressed the need for support from peers and tutors and patience from the lecturer. They also expect lectures to be interesting and to be managed in such a way that students are not allowed to act disruptively. They want an atmosphere where they will feel safe to ask questions.

Students mentioned aspects of their own behaviour that could affect their progress. They mentioned procrastination; poor time management; lack of understanding and fear of asking questions. Financial worries were a motivating influence for some students but others found such concerns devastating. Self motivation and a positive attitude; self worth and the drive to succeed were all perceived to be crucial to success. In addition peer pressure – the need to fit in and being part of a circle of positive friends and having a realistic self image were mentioned as important. Some students added that they needed to socialise and that they often gave this priority over their studies. Although the overwhelming majority of students had high praise for the self-study CD, as reported in Table 1, very few of them actually used it (Marais, 2008).

10. Discussion

Students were able to identify the correct answer more easily when they were able to select from possible given representations. It is possible that by using the tactile models ("Lego" blocks) when the initial worksheets were introduced students had been enabled to picture the graphic illustrations more easily. The problem may, however, be more complex but when neither the blocks nor illustrations were provided the majority remained unable to transcend from the symbolic chemical reaction formula to a graphic picture of what it represented.

Chemistry, like mathematics, requires students to spend additional time attempting problems. Stoichiometry, which is a more complex application of fundamental principles, certainly requires more time and practice. The concepts must be understood, not memorised, and reinforcement is one of the ways to ensure success. The provided CD contained many such additional examples and exercises, but, if the students were not sufficiently motivated to use it they would continue to have difficulty with this crucial part of the syllabus. Clearly a lot more work is still needed in this area. Researchers at Pretoria University, South Africa, on finding similar results tested students' levels of confidence (Potgieter et al., 2007). The results of their work indicated that students with the lowest levels of ability actually had unrealistically high levels of confidence than their answers suggested. It is possible that the students at TUT share the same unrealistic evaluation of their own abilities. This would definitely account for them believing that they did not need additional work beyond what is done during the lecture time. An investigation into the confidence levels and actual understanding of the 326 first year chemistry students who registered for the 2009 academic year is currently being undertaken. It should therefore be stated that the main contribution of this chapter lays not so much in extending the frontiers of knowledge, but rather in those of practice. The means in which learning content is presented rather than the content itself is highlighted and the teaching practice found most effective is described.

11. References

Bennett, S.W. (2005). Problem solving in chemistry. *Workshop on science education.* Unpublished, Tshwane University of Technology. Pretoria.

Berlyne, D.E. (1965). Curiosity and education. In: *Learning and the educational process,* J.D. Krumboltz (Ed.), Rand, McNally & Co., Chicago.

Blank, W. (1997). Authentic instruction. In: *Promising practices for connecting high school to the real world.* W.D. Blank & S. Harwell (Eds.), (pp. 15-21), Tampa FL: University of South Florida: ERIC document reproduction service no. ED407586

Botha, H.L. & Celliers, C.D. (1999). Preparedness for University study: Designing a thinking skills test. *South African Journal for Higher Education,* Vol 13., No 1., (pp. 144-152).

Brosnan, T. & Reynolds, Y. (2007). Investigating understanding of chemical and physical change. *Available online.* Retrieved from: www.ipn.uni-kiel.de/projekte/eserab125-bro. Accessed: 2nd February 2007.

Chalmers, A.F. (1999). *What is this thing called science?* (pp. 1-9), Hackett, Indianapolis.

Clark, R. (1994). Media will never influence learning. *Educational technology research and development,* Vol 42., No 2., (pp. 21-29).

Dev, P.C. (1997). Intrinsic motivation and academic achievement. What does their relationship imply for the classroom teacher? *Remedial and special education,* Vol 18., No 1., (pp. 12-19).

Dewey, J. (1910). *How we think.* Heath, Boston.

Festinger, L. (1957). *A theory of cognitive dissonance.* Harper and Row, New York

Fetherstonhaugh, T. & Treagust, D.F. (1992). Student's understanding of light and its properties: Teaching to engender conceptual change. *Science Education,* Vol 76., No 6., (pp. 653-672).

Fraser, W.J. & Killen, R. (2003). Factors influencing success or failure of first year and senior university students: do education students and lecturers perceive things differently? *South African journal of education,* Vol 23., No 4., (pp. 254-263).

Gabel, D.L. & Bunce, D.M. (1994). Research on problem solving: Chemistry. In:*handbook of research on science teaching and learning. A project of the National Science teachers' association.* D.L. Gabel (Ed.), (pp. 301-325), Macmillan, New York.

Gummow, R. (2007). Structured worksheet design. *Unpublished,* Tshwane University of Technology, Pretoria.

Hewson, P.W. & Hewson, M.G. (1984). The role of conceptual conflict in conceptual change and the design of science instruction. *Instructional Science,* Vol 13., (pp. 1-13).

Kilfoil, W.R. (1999). The linguistic competence of science students. *South African Journal of Higher Education,* Vol 13., No 1., (pp. 46-58).

Kushman, J.W.; Sieber, C. & Heariold-Kinney, P. (2000). This isn't the place for me: school dropout. In: *Youth at risk: A prevention resource for counselors, teachers and parents. 3rd ed.* D. Capuzzi & D.R. Gross (Eds.), (pp. 471-507), American counseling association, Alexandria, VA.

Marais, F. & Gummow, R. (2007). Computer-aided instruction for students registered for first year chemistry: An intervention at Tshwane University of Technology. *Unpublished paper, presented at the Higher Education Learning & Technology Association of South Africa (HELTASA) conference,* Bloemfontein, 19-21 November. Submitted for publication in *Journal for New Generation Sciences.*

Marais, F. & Louw, I. (2008). The influence of prior learning as a barrier to learning for students studying chemistry, *Proceedings of International Technology Education & Development (INTED) conference,* pp. 531-544, IATED, Valencia, Spain.

Marais, F. (2008). The use of structured worksheets as a tool to target identified learning difficulties of first year chemistry students. *Unpublished paper, presented at the International Conference on Chemical Education (ICCE),* Mauritius, 3rd – 8th August.

Marais, F. & Combrinck, S. (2009). An approach to dealing with the difficulties undergraduate chemistry students experience with stoichiometry. *Accepted for publication in South African Journal of Chemistry,* Vol 62., (pp. 88-96)

Mulford, D.R. & Robinson, W.R. (2002). An inventory for alternate conceptions amongst first year general chemistry students, *Journal of Chemical Education,* Vol 79., (pp. 739-744).

Nussbaum, J. & Novik, S. (1982). Alternative frameworks, conceptual conflicts and accommodation: Towards a principles teaching strategy. *Instructional Science,* Vol 11., (pp. 183-200).

Piagèt, J. (1964). Development and learning. *Journal of Research in Science Teaching,* Vol 2., (pp. 176-186).

Park, T. (2003). Re-thinking and Re-imagining higher education: Why? *South African Journal of Higher Education,* Vol 17., No 3., (pp. 5-8).

Potgieter, M.; Davidowitz, B. & Mathabatha, S. (2007). Do they know that they don't know? The relationship between confidence and performance of first year chemistry students at three tertiary institutions in South Africa. *Unpublished paper presented at Australasian Science Education Research Association (ASERA) conference,* 20th – 23rd April, Freemantle, Australia.

Ramose, M. (2003). Transforming education in South Africa: Paradigm shift or change? *South African Journal of Higher Education,* Vol 17., No 3., (pp. 137-143).

Scalise, K.; Claesgens, R.; Kristianiak, R.; Mebane, S.; Wilson, M. & Stacy, A. (2003). Perspectives of chemists: Tracking conceptual understanding of student learning in chemistry at the secondary and university levels. *Available online.* Retrieved from: http://www.cchem.berkeley.edu/amsgrp/ed. Accessed: 15th January 2007.

Tao, P.K. & Gunstone, R.F. (1999). The process of conceptual change in force and motion during computer-supported physics instruction. *Journal of Research in Science teaching,* Vol 36., No 7., (pp. 859-882).

Trumper, R. & Gorsky, P. (1993). The influence of alternative frameworks, cognitive levels and closed-mindedness. *Journal of Research in Science teaching,* Vol 30., No 7., (pp. 637-648).

Williams, J.M. & Tolmie, A. (2000). Conceptual change in biology: Group interaction and the understanding of inheritance. *British Journal of Developmental Psychology,* Vol 18., (pp. 625-649).

Woods, E.G. (1995). Reducing the dropout rate. *Available online*. Retrieved from: http:www.nwrel.org/scpd/sirs/9/co17.html. Accessed: 12th December 2007.

Yitbarak, S. (2006). Questions we ask and misconceptions of chemical concepts in African context. *Unpublished manuscript,* Retrieved from http:www.uni_muenster.de/imperia/md/content/did. Accessed: 12th March 2008.

Technology Education and Development

Edited by Aleksandar Lazinica and Carlos Calafate

ISBN 978-953-307-007-0
Hard cover, 528 pages
Publisher InTech

Published in print edition October, 2009

The widespread deployment and use of Information Technologies (IT) has paved the way for change in many fields of our societies. The Internet, mobile computing, social networks and many other advances in human communications have become essential to promote and boost education, technology and industry. On the education side, the new challenges related with the integration of IT technologies into all aspects of learning require revising the traditional educational paradigms that have prevailed for the last centuries. Additionally, the globalization of education and student mobility requirements are favoring a fluid interchange of tools, methodologies and evaluation strategies, which promote innovation at an accelerated pace. Curricular revisions are also taking place to achieved a more specialized education that is able to responds to the society's requirements in terms of professional training. In this process, guaranteeing quality has also become a critical issue. On the industrial and technological side, the focus on ecological developments is essential to achieve a sustainable degree of prosperity, and all efforts to promote greener societies are welcome. In this book we gather knowledge and experiences of different authors on all these topics, hoping to offer the reader a wider view of the revolution taking place within and without our educational centers. In summary, we believe that this book makes an important contribution to the fields of education and technology in these times of great change, offering a mean for experts in the different areas to share valuable experiences and points of view that we hope are enriching to the reader. Enjoy the book!

How to reference

Fiona Marais and Andile Mji (2009). Factors Contributing to Poor Performance of First Year Chemistry Students, Technology Education and Development, Aleksandar Lazinica and Carlos Calafate (Ed.), ISBN: 978-953-307-007-0, InTech, Available from: http://www.intechopen.com/books/technology-education-and-development/factors-contributing-to-poor-performance-of-first-year-chemistry-students

INTECH
open science | open minds

InTech Europe
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166

InTech China
Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821