COMBINING LECTURES WITH COOPERATIVE LEARNING STRATEGIES TO ENHANCE LEARNING OF NATURAL PRODUCTS CHEMISTRY

Takawira KAZEMBE
University of Zimbabwe, ZIMBABWE

Abstract. Two groups of students enrolled for a degree in chemistry teaching at a State University in Zimbabwe and were taught natural products chemistry during their final year in 2004. One group comprised of students who had completed A' level studies (regular entry group) and the other comprised of students who had qualified through teacher training colleges, taught for a minimum of two years, then enrolled for BSc. degree studies (late entry group). The two groups were taught natural products chemistry similarly by one lecturer but differed in the way they studied outside lecture periods. The late entry group voluntarily studied as a cooperative whilst the regular entry group worked as individuals. The group that employed cooperative learning strategies had superior clearance of misconceptions and retention of concepts and factual information as revealed by assignments and tests results. Cooperative learning is a powerful strategy for conceptual change as revealed by assignment and test scores for the two groups of students.

Keywords: conceptual change; cooperative learning; misconceptions; natural products chemistry; reaction mechanisms; drug action; efficacy; herbal medicines

Introduction

Today's chemistry lecturer is both the traditional information giver and a guide-on-the-side as he/she uses the more modern style of facilitating student learning. He/she still summarizes books for the student who comes to class and have the important sections of the textbook read for him/her. The student will be comfortable in the knowledge that lecturers often feel uncomfortable including examination questions on areas they have not covered in class, as if telling is teaching. The lecturers traditionally use behaviorist philosophies of printed syllabi, behavioral/ course objectives, and sample tests.

However, education systems are moving towards helping students to master skills that help them to reach to information themselves, rather than the lecturer transmitting information to them. Students are expected to produce information and reach to the information that they will need to develop problem solving skills. Science education should be a student-centered learning process with the teacher trying to understand the student's construction of knowledge and providing guidance. The teacher should facilitate learning process by asking effective questions and guide students to the right resources. The student should reflect, arrange, and inter-relate the different bits of information.

Students hold a variety of scientifically faulty ideas (misconceptions) which may prevent them from reaching scientifically proved realities and make it hard or even impossible for them to gain new information. Reflective teaching strategies to overcome misconceptions and enable meaningful subsequent learning are required if the affected students are to benefit from subsequent lessons. The misconceptions may be revealed during normal topic discussions, during lessons, in assignments or in test answer scripts, and the teacher needs to institute effective teaching strategies to overcome them.

Methods to overcome misconceptions are very important in science and technology education. The conceptual change approach has frequently been used to integrate new information with enacted experiences. Misconceptions are supposed to be remedied by revision and the modification of previous knowledge to make it compatible with new information to allow meaningful learning. Such treatment facilitates the transition from misconception to information that is accepted as scientific, a conceptual change process [1,2]. Group work and demonstrative experiments facilitate conceptual change by allowing students to feel out misconceptions and correct them through demonstrations, discussions and examination of answers to questions raised during the process.

Teachers need to be aware of students' prior knowledge and possible misconceptions before they teach and be able to cater for them during lesson planning. They develop strategies that enable students to become aware of their misconceptions, realize scientific facts and combine them with their prior knowledge. This has the effect of making the students explorers and constructers of knowledge, a necessary undertaking that simplifies the teaching of concepts [3].

Research reveals that it is hard to eliminate misconceptions through traditional approaches because it is a permanent and continuous process. It is not sufficient to develop right concepts on students [4], hence, there is a need to teach pre-service teachers using effective instructional approaches which overcome misconceptions and facilitate meaningful learning. Group work and assignments based on the conceptual change approach are useful for such purposes, as they assist towards satisfying the conditions necessary for conceptual change to take place as proposed by Posner et al. [5]: (1) students must become dissatisfied with their existing conceptions; (2) the new concept must be clear and understandable for students; (3) the current problem should be solved by using the new concept; (4) similar future problems can be solved by using the new concept.

Most misconceptions in chemistry derive from the learners' understanding of prior chemistry teaching. When students fail to represent concepts they have been taught they tend to simplify the concepts and develop misconceptions in the process. Since misconceptions stem largely from the way the students have been taught and will impede further learning, they have also been labeled as pedagogic learning impediments [6-8]. The problem of misconceptions is exacerbated by textbooks and teachers as they present information as if everything is very simple and clear, tending to present science as a collection of true or complete facts. Presentation of facts, generalizations and mathematical formulations as if the information had been 'read directly from nature' may be deluding and misleading [9]. It is, therefore necessary to ensure that student teachers are taught properly so that they do not propagate misconceptions in the classes they teach upon leaving training institutions.

Teachers need to help students desist from learning passively (not directly participating in the learning process, but taking on the role of "receptacles of knowledge"), and be involved in active learning, doing something besides listening [10]. Factors that promote active learning in the classroom include: (1) involving students in anything more than listening, (2) placing less emphasis on transmitting information and more on developing students skills, (3) involving students in higher-order thinking (analysis, synthesis, evaluation), (4) engaging in activities (e.g., reading, discussing, writing), (5) placing greater emphasis on students' explorations of their own attitudes and values, or (6) anything that involves students doing things and thinking about the things they are doing. Hence, teachers need to create conditions for students to care about what they want them to learn since students learn what they care about and remember what they understand [11].

Students prefer strategies promoting active learning to traditional lectures. The traditional lecture method creates a predominantly passive learning experience where students are exposed to information, but with little opportunity to process it. Active processing of information increases the likelihood of recalling it later. The required reflection on, relating to, and examining concepts as they are presented is unlikely to occur in traditional lecture classes because the constant stream of information leaves students scrambling to take accurate notes. However, traditional lectures can be modified to incorporate active learning in the classroom. An occasional pause during a lecture to allow students to consolidate their notes will, thus, enable students to learn significantly more information [12-14].

Students have strong preferences about working alone, in a pair, with a peer, in groups/teams, with a teacher/adult, or with a friend [15]. These learning styles tend to be relatively stable over time (they are predictable), but one cannot expect completely static traits, variations occur in learning preferences from day to day, week to week, etc.

Cooperative learning activities enable students to develop a feeling of community in the classroom and create a positive force that promotes achievement through commitment and mutual goals in learning. Cooperative learning activities nurture an environment in which a wider range of student learning styles is supported, and most collaborative references indicate that the best cooperative groups mix students with different learning styles [16].

The field of natural herbal remedies has flourished over the past few years as medicines of natural origin have become increasingly popular. Botanical products from various continents and cultures are sold in health food stores, drug stores and supermarkets, in catalogs and via the internet, to an eager, receptive public seeking safe, effective alternatives to pharmaceutical drugs.

Although there has been an increase in the use of herbal medicines to treat a broad range of medical conditions in recent years, many questions remain concerning their quality, safety and efficacy. Many of the pharmaceuticals available to Western physicians today started off as herbal remedies, for example opium, aspirin, digitalis, and quinine. As much as 80% of the indigenous populations in developing countries depend on medicinal plants and traditional systems of medicine as their primary source of healthcare. Herbal medicines account for an important share of the pharmaceutical market even in the developed world, for example the annual herbal medicines sales approximated US$7 billion within the European Community, and exceeded $3.3 billion in the US in 1997.

The safety considerations emerging with herbal medicinal products reflect a growing market, largely unregulated, and arise due to lack of effective quality controls. The ingredients of herbal medicines are complex mixtures and the concentrations can vary considerably depending on environmental and genetic factors. The constituents responsible for claimed therapeutic effects are frequently unknown or only partly understood. However, in 1995, the Traditional Medicine Program of the WHO began efforts to standardize the proper use of herbal medicines throughout the world.[1)]

A common misconception about the use of ‘natural’ products is that ‘natural’ equals ‘safe to use’. Herbs can produce undesirable side-effects just as pharmaceutical products can. Further more, taking the herbal remedy concomitantly with other medicinal drugs may lead to the danger of ‘summation’ since two drugs having similar actions may add together to produce an overdose.

Reported adverse effects of herbal remedies include allergic reactions, toxic reactions, adverse effects related to a herb’s desired pharmacological actions, possible mutagenic effects, drug interactions, drug contamination and even mistaken plant identities.[1)]

Students’ misconceptions in natural products chemistry after formal instruction can be broadly categorized into: (1) enacted informal ideas that emanate from everyday experiences, cultural and religious expectations, peer group and other environmental pressures; (2) incomplete or improper views developed by students during instruction; and (3) imprecise, misleading or erroneous concepts transmitted by teachers as well as by textbooks.

Misconceptions of the first type are generated through students’ life experiences and indiscriminate use of everyday language. They are commonly detected in basic scientific concepts which are encountered by students in real-life contexts prior to instruction, such as the efficacy of plant drugs, their mode of action, their purity, concept of living. Being established in the cognitive structure before the receipt of formal instruction, these informal preconceptions have been found to be highly resistant to change and to subsequently block the learning of approved science concepts. They may be effectively tackled by instructional strategies that take students’ pre-existing ideas into account. For certain topics, particularly those that are concerned with more complex or abstract phenomena such as biosynthetic mechanisms, mechanisms of drug action, students are less likely to come into immediate and direct contact with them in daily life, and so have little chance to develop their own ‘naive’ explanations [17]. These errors are mainly caused by ineffective learning or poor teaching in the preceding courses, resulting in lack of understanding during instruction which may be caused by a variety of factors. Students may form improper or distorted views if the prerequisite knowledge necessary for the construction of a new concept is absent from the cognitive structure. To promote conceptual change, students have to master the anchoring concepts before instruction [18,19]. Undue emphasis on the acquisition of factual information, which is a common practice in natural products chemistry teaching, presents a block to conceptual development. When presented with excessive detail, students tend to resort to a rote learning style, incorporating new concepts as isolated information with little understanding or integration [16].

Teachers who are less competent in subject-matter knowledge may propagate incomplete or erroneous views to their students through inaccurate teaching or uncritical use of textbooks [20,21]. The students resort to rote learning with unconditional acceptance of information delivered by the teacher. Curriculum developers assume that secondary school teachers, being graduates in the appropriate discipline, should possess adequate subject knowledge for teaching the required content of the secondary school curriculum and they should be competent in translating their subject-matter knowledge into curriculum materials for instruction in the classroom. As a result, most teacher education programmes focus mainly on educational principles, instructional methodology and teaching practice; and seldom address the need to promote a deeper understanding of subject-matter knowledge that is necessary in making a teacher more competent in teaching [22-24].

In attempting to present a complex idea in a simplified way that is appropriate to the level of the students, teachers and textbooks often use imprecise terms or statements that are open to different interpretations. Without an in-depth treatment of the topics involved, students are often misled by such terms or statements and develop conceptual errors. To avoid this, teachers should use textbooks more critically and selectively, and be alert to possible inaccuracies of information described in textbooks [16].

Some misconceptions are reinforced in textbooks and practical manuals. In order to provide a simplified picture that is comprehensible to students, many textbooks use inaccurate expressions that may lead to misunderstanding [25]. In stead, teachers should master the details of the principles which may be too demanding for students to comprehend so that they may be able to present a simplified and yet precise version of the relationships without losing accuracy. Meaningful learning can also be enhanced by ensuring that, before teaching the particular section; the students have acquired the pre-requisite concepts before receiving instruction on, for example, the mechanism of the reactions in question.

To avoid propagating wrong ideas to students, it is necessary to strengthen teachers' understanding of topics in their undergraduate courses or postgraduate teacher education programmes. A good grasp of the mechanism involved will enable the teachers to produce simplified and yet accurate versions of the process for presentation to their students [16]. It is, thus, desirable to explore strategies to assist the student teacher master the study of natural products chemistry before he leaves for his/her encounters with his/her students in the field.

Research question

1. What is the value of teaching natural products chemistry to secondary school student teachers?

2. Is there a difference between the misconceptions held by late entry students and those held by normal entry students?

3. Is there a difference in the persistence of the two groups' misconceptions after instruction?

4. What makes the late entry students obtain results which appear to be better than those obtained by regular entry students?

Methodology

Delimitation of the study and sampling

The study was carried out in the chemistry department at one of the state universities in Zimbabwe in 2004. The chemistry department enrolled two streams of students: a regular entry group and a late entry group. The regular entry group consisted of 25 students: 18 male and 7 female (23-26 years of age, at the time they took the course during their final year at the university). The late-entry group consisted of 15 students: 14 male and 1 female (27-35 years of age in their final year at the university).

Most regular entry students joined the university straight after A' levels, and thus, consisted of members who had not yet been initiated into working life. They tended to work as individuals.

The late-entry students studied for teaching qualifications at teacher training colleges after O' levels or after failing to enter university after attempting A' levels. They graduated from teacher-training colleges after 3 years of training and worked for at least 2 years before they could enroll for the courses at the university after obtaining the requisite A' levels necessary for university entry. The members were united by the life experiences they had met between leaving teacher training colleges and enrolling at university. They were united by the desire to get the qualification and return to their families. They realized that they would increase chances to succeed if they worked as a group.

Instruments

The two groups were taught by the same lecturer using identical teaching styles. The students were asked to commend on the need for them to study natural product chemistry. They were also required to write down what they knew about some questions for which the answers would expose the student's prior knowledge of natural products chemistry. The exercise was to be completed in class after sufficient time was given. The lecturer examined the answers and used them in lesson plans.

Metacognitive approaches to instruction were employed to increase transfer of information, build upon prior experiences, and replace misconceptions. This also helped students to become more aware of their own learning styles and could then better self assess their understanding of concepts. Students were encouraged to function as independent thinkers by providing them with opportunities that allowed for greater student involvement and initiative. Learning was enhanced by paying attention to the knowledge and beliefs that students brought to the learning tasks and the knowledge was used as a starting point for new instruction. Students' changing conceptions were monitored as instruction proceeded. Tasks that embodied known misconceptions were selected to help students test their thinking and see how and why various ideas needed to change.[2)] The late entry students practiced cooperative learning style activities outside time tabled lecture periods. The lecturer knew about the practice but did not interfere. He observed the student activities, discussed some of his findings with the students and recorded his observations.

Data collection

Discussions, observations, assignments, and tests were used as data collecting instruments. The discussions were held during the tutorial periods. The students would be given problems to discuss and any misconceptions individuals had would surface and be recorded during the discussions. The students were observed as they studied during their free periods on the university grounds, in free lecture rooms, in the laboratories, or in the library. Assignment questions were structured such that the presence of misconceptions would be revealed in the assignment answers. The lecturer would record and analyze for individual students with particular attention to misconceptions, even those collected during informal observations and discussions.

Results

Need to study natural products chemistry by secondary school student teachers

The student teachers argued that they needed to study natural product chemistry because 80% of their students and the families they came from used natural product chemicals for their primary health care needs. Further to that, most people in the rural areas, besides the use of herbal medicines, consume natural products in the wild fruits they collect from their environment. Hence natural products were part of their environment and as such they needed to know about them. Some students (10 from the normal stream and none from the late entry stream) supported the study of natural products chemistry for a different reason. They felt that they should study them because they needed to be armed for the job of discrediting the practice of consuming herbal medicines. They felt that the study would enable them to collect facts that would enhance the cause of their religious affiliations. Apart from that, the majority of the students also felt that since herbal medicines were part of their culture and natural products chemistry study was an important step towards understanding herbal medicines, they needed to study it so as to understand their culture. Most of the students also believed that herbal medicines would be an important aspect of their students enacted worldviews, hence knowledge of natural products chemistry would empower them to appreciate some of their own students' enacted worldviews.

Common misconceptions about the drugs in traditional medicines

1. There are no medicinal drugs in the edible fruits collected from the wild. (91%);
2. The bitterness in medicinal plants was due to the drugs they possessed. (83%);
3. All hospital drugs are synthetically manufactured. (85%);
4. All drugs sold in chemists' shops are chemically pure. (100%);

5.. Drugs extracted from plants and purified will react differently to identical synthetically manufactured drugs. ((87%);

6. Biochemical reactions are as reversible as laboratory bench reactions are. (50%);

7. Lock and key mechanisms of drug action? (50%);

8. The transition states which are met in laboratory organic chemistry reaction mechanisms are identical with those met in biochemical reactions. (40%);

9. The only difference between biochemical reactions and the normal bench reactions were the temperatures at which they took place. (91%);

10. Traditional medicines gave no side reactions, (80%);

11. Traditional medicines are safe to use because they are natural. (80%);

12. Traditional medicines do not give harmful side effects because they are natural and nature would not harm itself. (80%);

13. Traditional medicines are not safe to use because they are not pure. (45%);

14. Traditional medicines should not be compared with hospital medicines because hospital medicines are pure. (50%);

15. Hospital medicines are always safe and do not give side effects. (50%);

16. All hospital medicines are laboratory synthetic chemicals. (85%);

17. Plant drugs never find their way into hospital medicines. (86%).

Persistence of misconceptions

Regular entry students

Misconceptions kept recurring even after they had been discussed during a lecture or as part of feedback to an assignment. Some persisted even into examinations answers.

Late entry students

Most misconceptions were not observed after they had been discussed during a lecture or as part of feedback to an assignment.

Assignment results (%)

	Regular entry students	Late entry students
Range	46-77	60-76
Average	60.5	66.5

Test results (%)

	Regular entry students	Late entry students
Range	56-78	69-76
Average	64.7	72.5

Discussion

Support for the study of natural products chemistry

The student teachers supported the study of natural products chemistry, although for varied reasons. The main reason given in support of the study was that natural products chemicals were responsible for the efficacies of traditional medicines. Those who did not support the study appeared to be governed by their religious affiliations. They belonged to church organizations which are against the medical treatment of their faithful. They were vociferous during discussions but giving arguments which appeared flimsy. Wanting to study natural products chemistry for cultural reasons was also accepted as an honest response. Many people use herbal medicines secretly, including those who vociferously denounce the practice in public.

That the study of natural products chemistry was supported was encouraging because it meant that the whole group would work in common purpose towards a cause they supported. As the students pointed out, it was desirable to study the subject because it involved a practice subscribed to by a large portion of the people in the environment they would work in and as teachers they needed to understand their environment.

Misconceptions about drugs

The common misconceptions about the drugs in traditional medicines revealed the prevalence of a number of conceptual errors which were held by the student-teachers. The problem was attributed to students' inadequate exposure to subject knowledge. The students had not received any formal training in natural products chemistry and all they had were enacted worldviews resulting from interaction with peers at school, formed from everyday experiences at home, from culture, from religious organizations, and erroneous concepts propagated by reading materials as well as some textbooks. These informal preconceptions have been found to be resistant to change and to subsequently block the learning of approved scientific concepts. They can be effectively tackled only by instructional approaches that take students' pre-existing ideas into account [16].

Specific teaching strategies were required so as to relieve the students of these misconceptions and prevent the propagation of the misconceptions to their own students after graduation. Cooperative learning in small groups give students an opportunity to identify and remedy their misconceptions in a non-threatening environment. Students who work collaboratively learn faster and more efficiently, have greater retention and feel more positive about the learning experience. Cooperative learning has significant effects on academic peer relationships and social development. The students help each other to comprehend and accomplish tasks as well as put in more effort into their work and even criticize one another if necessary [26,27].

Teaching large groups using cooperative strategies is cumbersome. But it is possible for students to organize themselves and study cooperatively side-by-side with the formal lecture attendance. The late entry group organized themselves into such a cooperative voluntarily and by their own volition. They were impressive with the hard work which was revealed in their educational enterprise. Lecturers felt that they worked hard because they felt that without working harder than the younger students whom they felt were more academically gifted than they, they might not graduate. However, it is more likely that they were influenced by the cooperative that they had embarked on, and maintained the cooperative learning styles throughout their academic activities. Such students continue to work so that they become confident of receiving sufficient knowledge. They heeded the observation that students do not learn much by just sitting in class listening to teachers, memorizing notes, and spiting out answers. They need to talk about what they are learning, write about it, relate it to past experiences, apply it to their daily lives and make what they learn part of themselves. This also agreed with most experts who advocate that students learn best when they take an active role in the education process, discussing what they read, practicing what they learn, and applying concepts and ideas [28-30].

These students benefited immensely from their working style and obtained results that surprised most lecturers in the department. They were, however, ripping the benefits of cooperative learning styles which exposed them to situations that enabled them to clear grey areas in their prior knowledge. The most important aspect of prior knowledge that influences meaningful learning is the degree of mastery of the original material in the prior knowledge. Peer instruction significantly enhances mastery of that original material. Cooperative learning is rooted in peer instruction. It enables learners to receive positive feedback from the process of thinking, problem solving and group interaction, resulting in better skills and comprehension of educational concepts as well as in task sharing. Students learn to organize their thoughts and orient themselves for complex educational tasks and are pushed to present logical explanations, resulting in deeper understanding of educational concepts [27,31,32]. The late entry students' success was based on cooperative learning which brought with it all the benefits of learning in a group, sharing both the burden and rewards of active involvement.

Non-cooperative students attempt to transfer knowledge by doing exercises, a practice that does not give them much opportunity to think beyond the current problem. The late entry group of students combined the benefits of the formal lectures with cooperative activities to good effect. By combining lectures and cooperative activities they kept themselves interested and involved in their studies in an excellent way [33]. Active involvement enhanced their understanding and ability to integrate and synthesize material and also improved their conceptualization of systems and how they function and increased retention. Students involved in cooperative learning will have better understanding and decreased rate of forgetting [34,35].

The regular entry students, because they were non-cooperative students, failed to partake in the benefits of the active involvement characteristic of cooperative learning. By working as a group the cooperative students interacted with each other, appreciated interpersonal differences, built on individual strengths, sharing responsibility for learning while engaging in the learning process, and worked toward common goals. The practice provided a shared experience upon which reflection and class discussion could build. The learning environment so created was conducive to the application of the constructive learning model. They could remind one another of some of the prerequisite prior knowledge applicable to current situations. Thus, the late entry students created, for themselves, an enabling environment that allowed them to reflect, generalize and apply the information they got from lectures, enhancing their learning efficiency in the process. They operated a cooperative learning model which ran parallel to the timetabled lectures. They attended lectures, discussed lectures, consulted reference sources, consolidated their notes in a group or regrouped to discuss problems, or to do assignments or other work. Their learning environment was characteristic of active learning. Thus, they effectively combined lectures with cooperative activities in a way that excellently nurtured interest and involvement, leading to group and individual academic empowerment.

In contrast, the younger students concentrated on doing exercises as individuals, reading reference materials such as books and journal articles, and consolidating their notes. They did not discuss curriculum materials outside stipulated timetabled periods except on consultation with a colleague to get help to solve a problem here and there or during the occasional consultations with a member of staff, including lecturers. Members of this group depended on individual learning capabilities without much to enhance whatever active learning activities that may take place in the timetabled learning sessions. In contrast to members of the other group, the way some of the students of the regular stream expressed themselves in assignments and tests was suggestive of rote memorization and verbatim recall of information.

Correction of misconceptions for members of this group was met with problems. The students needed to be reminded of the presence of misconceptions in their answers now and again throughout the semester. The case was different for the other group, where recurrence of misconceptions was seldom, suggestive of rote learning in the regular entry group, and more meaningful learning taking place with the late entry group.

That the late entry students could clear their misconceptions more efficiently might mean that the group discussed the misconceptions in their after lecture meetings, affording the perpetrators the opportunity to reflect and embark on corrective actions. Even those which were discovered in assignment answers were not repeated either by the original writer or by any other member of the group. In contrast, misconceptions by members of the regular entry group re-surfaced throughout the course of the semester. This might not have happened had the students carried out postmortems of lectures or discussed assignments, as was the case with the late entry group.

***Assignment and test results* (%)**

Assignment results (average: 66.5 and range: 60-76) and test results (average:72.5 and range: 69-76) of late entry students were better than those of regular entry students: assignments results (average: 60.5 and range: 50-70) and test results (average: 64.7 and range: 56-78).

Based on university entry credentials, the regular entry students were academically more gifted than the late entry students. The regular entry students had qualified to enroll for university studies straight from school without any negotiations. Most of the late entry students had failed to enter into A' level studies and had to enroll for teacher training courses which were less academically demanding. The better average scores they were obtaining were probably a result of the study styles they had embarked on and hard work. A student's conceptual understanding is developed by interacting with concepts in the context of problems, trying to articulate them clearly and concisely, explaining them to others, and getting misconceptions corrected through discussion with people more knowledgeable. The working style of the late entry group enabled the students apply this with applausive benefits, as they worked as a group, carrying one another up the ladder to mutual success. Such benefits did not accrue to the regular entry students as they worked as individuals, one for oneself, and the spirit of competition was evident. These students did not take heed of Cross's findings [36] that students who are actively involved in learning learn more than students who are passive recipients of instruction, since students learn by becoming involved, devoting physical and psychological energy to academic experience. To be actively involved, students must read, write, discuss, or be engaged in solving problems. They must engage in such higher-order thinking tasks as analysis, synthesis, and evaluation. These are characteristics found in cooperative studying situations as was practiced by the late entry group whom these youngsters chided as the old ones. Instead, they would have been better off emulating them.

Conclusion

Inclusion of cooperative learning, complementing the lecture style of instruction cooperative learning should be encouraged in order to give students an opportunity to identify and remediate their misconceptions in a non-threatening environment [26]. The efficacy of cooperative learning as a learning strategy is not only in connection with misconceptions. It pervades all learning environments and teachers should consider including aspects of the cooperative learning model in their attempts to share the passion they feel about their content area by creating enabling environments for students to partake in active learning.

NOTES

1. Herbal Medicinal Products: Quality, Safety and Efficacy Considerations. Pharmalink Consulting Inc., 2005.

2. McLean, V. http://arexpeditions.montana.edu/article_upload/McLean.doc

REFERENCES

1. Smith, E.L., T.D. Blakeslee, C.W. Anderson. Teaching Strategies Associated with Conceptual Change Learning in Science. *J. Research Science Teaching* **30**, 111-126 (1993).

2. Chambers, S.K., T. Andre. Gender, Prior Knowledge, Interest and Experience in Electricity and Conceptual Change Text Manipulations in Learning about Direct Current. *J. Research Science Teaching* **34**, 107-123 (1997).

3. Çaycı, B., M.K. Demir, M. Başaran, M. Demir. Concept Teaching via Cooperative Learning in Social Sciences Class. *Kastamonu Education J.* **15**, 619-630 (2007).

4. Tekkaya, C., Y. Çapa, Ö. Yılmaz. Pre-Service Biology Teachers' Misconceptions about Biology. *J. Hacattepe Univ. Educ. Fac.* **18**, 140-147 (2000).

5. Posner, G.J., W.A. Gertzog. The Clinical Interview and the Measurement of Conceptual Change. *Science Education* **66**, 195-209 (1982).

6. Griffiths, A., K. Preston. Grade-12 Students' Misconceptions Relating to Fundamental Characteristics of Atoms and Molecules. *J. Research Science Teaching* **29** 611-628 (1992).

7. Taber, K.S. Building the Structural Concepts of Chemistry: Some Considerations from Educational Research. *Chem. Educ. Res. Pract.* **2**, 123-158 (2001).

8. Taber, K.S. The Mismatch between Assumed Prior Knowledge and the Learners' Conceptions: A Typology of Learning Impediments. *Educational Studies* **27**, 159-171 (2001).

9. Yofrach, M. Definition of Chemical Literacy and Assessment of Its Attainment in High School Chemistry. *Chem. Educ. Res. Pract.* **5**, 301-325 (2004).

10. Cibik, A., E.H. Diken, E.S. Darçin. The Effect of Group Works and Demonstrative Experiments Based on Conceptual Change Approach: Photosynthesis and Respiration. *Asia-Pacific Forum Science Learning & Teaching* **9**, issue 2, art. 2 (2008).

11. Erickson, S.C. *The Essence of Good Teaching: Helping Students learn and Remember What They Learn*. Jossey-Bass, San Francisco, 1984.

12. Penner, J.G. *Why Many College Teachers Cannot Lecture.* Thomas, Springfield, 1984.

13. Ruhl, K.L., C.A. Hughes, P.J. Schloss. Using the Pause Procedure to Enhance Lecture Recall. *Teacher Education & Special Education* **10**, 14-18 (1987).

14. Shakarian, D.C. Beyond Lecture: Active Learning Strategies That Work. *J. Physical Education, Recreation & Dance* **66**(5), 21-24 (1995).

15. Howell, K.M. Mentors in Teaching. *Language Arts* **63**, 160-167 (1986).

16. Yip, D.-y. Identification of Misconceptions in Novice Biology Teachers and Remedial Strategies for Improving Biology Learning. *Intern. J. Science Education* **20**, 461-477 (1998).

17. Lawson, A. The Acquisition of Biological Knowledge during Childhood: Cognitive Conflict or Tabula rasa? *J. Research Science Education* **25**, 185-199 (1988).

18. Ausubel, D.P. *Educational Psychology: A Cognitive View.* Holt, Rinehart & Winston, New York, 1968.

19. Garnett, P.J., P.J. Garnett, M.W. Hackling. Students' Alternative Conceptions in Chemistry: A Review of Research and Implications for Teaching and Learning. *Studies Science Education* **25**, 69-95 (1995).

20. Barrass, R. Some Misconceptions and Misunderstandings Perpetuated by Teachers and Textbooks in Biology. *J. Biological Education* **18**, 201-206 (1984).

21. Sanders, M. Erroneous Ideas about Respiration: The Teacher Factor. *J. Research Science Teaching* **30**, 919-934 (1993).

22. Hashweh, M.Z. Effect of Subject-Matter Knowledge in the Teaching of Biology and Physics. *Teaching & Teacher Education* **3**, 109-120 (1987).

23. Smith, D., D. Neale. The Construction of Subject Matter Knowledge in Primary Science Teaching. *Teaching & Teacher Education* **5**, 1-19 (1989).

24. Tamir, P. Professional and Personal Knowledge of Teachers and Teacher Education. *Teaching & Teacher Education* **7**, 263-268 (1991).

25. Wynsberghe, D.V., C.R. Noback, R. Carola. *Human Anatomy and Physiology.* McGraw-Hill, New York, 1995.

26. Huddle, P.A., A.E. Pillay. An In-dept Study of Misconceptions in Stoichiometry and Chemical Equilibrium at a South African University. *J. Research Science Teaching* **33**, 65-77 (1998).

27. Whicker, K.M., L. Bol, J.A. Nunnery. Cooperative in the Secondary Mathematics Classroom. *J. Educational Research* **91**, 42-48 (1997).

28. Liu, X., H.B. Kaplan, W. Risser. Decomposing the Reciprocal Relationship between Academic Achievement and General Self-Esteem. *Youth & Society* **24**, 124-148 (1992).

29. Chickering, A.W., Z.F. Gamson. Seven Principles for Good Practice in Undergraduate Education. *Amer. Assoc. Higher Educ. Bull.* **39**(7), 3-7 (1987).

30. Davis, B. *Tools for Teaching.* Jossey-Bass, San Francisco, 1993.

31. Stevens, R.E., R.E. Slavin. The Cooperation Elementary School: Effects on Students' Achievements, Attitudes and Social Relations. *American Educational Research* **32**, 327-337 (2005).

32. Cortright, R.N., H.L. Collins, S.E. Dicarlo. Peer Instruction Enhances Meaningful Learning: Ability to Solve Novel Problems. *Adv. Physiology Education* **29**, 107-11 (2005).

33. Carbone, E. *Teaching in Large Classes: Tools and Strategies.* Sage, Thousand Oaks, 1998.

34. Elliott, D.D. Promoting Critical Thinking in the Classroom. *Nursing Education* **21**, 49-52 (1993).

35. Fathi-Ashtiani, A., H.-A. Mohebbi, M. Ayubi, S.-H. Salini. Comparison of the Cooperative Learning Model and Traditional Learning Model on Academic Achievement. *J. Appl. Sciences* **7**, 137-140 (2007).

36. Cross, P.K. Teaching for Learning. *Amer. Assoc. Higher Educ. Bull.* **39**(8), 3-7 (1987).

✉ **Takawira Kazembe**,
Department of Science and Mathematics Education,
University of Zimbabwe,
P.O. Box MP 167, Harare, Zimbabwe
E-Mail: kazembetc@yahoo.co.uk