# PROMOTION OF SUSTAINABLE DEVELOPMENT THROUGH SELF-REGULATION PROCESS TOWARDS ENHANCED STUDENTS' INTEREST IN QUANTITATIVE CHEMICAL ANALYSIS

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## Abstract

The study was designed to investigate the efficacy of self-regulation process on students' interest in quantitative chemical analysis. 284 Senior Secondary class III students from secondary schools in Orlu Educational zone of Imo State participated in the study. The instrument, Quantitative Chemical Analysis Interest Scale (QCAIS) was used for data collection. The internal consistency of this instrument was established to be 0.67 using Cronbach alpha reliability. The data gathered were subjected to ANCOVA. The null hypothesis was rejected. The result of data analysis showed that self-regulation significantly enhanced students' interest in quantitative chemical analysis. This confirmed that transferring ownership of learning to students and involving them in the 'doing' of science enhance their interest and motivate them to develop 'soft skills' which are basic prerequisite for sustainable development.

## Introduction

Science is a human intellectual construct which demands that students must be actively engaged in thinking, if their understanding is to be secured. Successful science teaching requires that students make sense of what they are being taught and asked to learn. However, owing to role dominance of the teacher in traditional approaches, students do not engage in critical thinking. This results to rote learning with little transfer of knowledge. Salt (1998) observed that the 'talk and chalk' method hardly increased students' enthusiasm and interest and therefore cannot promote sustainability in the education sector. On the other hand education for sustainable development is about helping students to develop knowledge, understanding, values and skills from classroom practice (http://www.esdtoolkit.org/resources/ web_esd.htm). To achieve this efforts in science education need to refocus attention on instructional practices which promote understanding.

Self-regulation presupposes that students 'develop conceptual understanding through engagement in hands-on-activity' (Roychodhury and Roth, 1996:423). Being a major tenet of Piagetian constructivism, it assumes that learners are exposed to a variety of hands-on experiences where they understand what they do and are able to construct new level of understanding. It demands active involvement of learners to reflect on their learning (Fosnot, 1989). Self-regulated learning (Simons, 1992 and Biggs, 1987), means

> having the ability to (i) prepare one's own learning (ii) take the necessary steps to learn (iii) regulate one's learning (iv) provide self-feedback and judgement and (v) keep motivation high.

A self-regulated learner is able to execute learning activities that lead to knowledge, comprehension and higher order learning (Paris and Byrnes, 1989). These processes involve monitoring, reflection, testing, questioning and evaluation; essential ingredients for understanding the relationships in quantitative chemical analysis and active participation. Active participation generates enthusiasm (Salt, 1998), as learners become involved in the learning process. In the same vein, as learners effectively monitor and evaluate their own cognitive processes their interest/motivation is sustained.

Very often, in traditional approaches, teachers set the stages for learning and organise all the events of instruction. This view is supported by authors such as Ajeyalemi (1993) who observed that students are not exposed to practicals in quantitative chemical analysis until few months before the Senior School Certificate Examinations (SSCE). The fact that practicals are poorly organised in secondary schools (Akinleye, 1987) means that teachers make all the decisions and organise the stages for laboratory instructions giving students the opportunity to abdicate the responsibility of learning to them (teachers). This explains the observation given in Chief Examiners Report (1993) that among other weaknesses of students is 'non-familiarity with the rationale for common laboratory procedures and inadequate knowledge of standard laboratory practical activities'. On the other hand, chemistry is a field of study which can provide students with the intellectual, experimental and professional skills needed to be successful and scientifically informed citizens if the content is adequately understood.

Hence, laboratory activities are meant to offer students opportunities to experiences on what they are to learn in a direct way and to monitor the effectiveness of their own experimental method. They are also expected to: link previous theoretical knowledge with experimental designs, data analysis and experimental interpretation, laboratory results with theory (Havadala and Ashkenazi, 2007). Thus, laboratory activities are perceived as means of developing students' scientific thinking, understanding and higher order cognitive skills (Nakhleh, Polles and Malina, 2002). To enable students develop some 'soft skills' (such as communicative skills, critical thinking and problem-solving skills, team work, entrepreneurship skills and leadership skills) which are embedded in experiments involving quantitative chemical analysis they should be encouraged to design and organise some instructional materials for the experiments. This is a basic requirement in self-regulation and sustainable education.

Based on this, several authors for example, Schneider, Krajcik and Blumenfield (2005) have affirmed the need for science education reforms to focus attention on classrooms and how teachers can improve their instructional practices. Reformers such as (Brown and Campione, 1994; Ministrell and Van Zoe, 2000) emphasised that students should be active participators in the learning process and that conversations in the classroom during practicals should engender deep understanding of science concepts. Despite research efforts to abate rote memorisation in chemistry and to improve students' interest in the subject, studies reiterate the teaching of science through the inquiry-based, hands-on and project-based approaches that address issues related to sustainability (Malcom, Cetto, Dickson, Gaillard, Schaeffer and Quere, 2002). This study therefore sought to examine the extent to which self-regulation will enhance students' interest in quantitative chemical analysis and through the self-regulatory approaches used during the laboratory work develop generic/'soft skills' as well as capacity to facilitate sustainable development.

**Hypothesis**

There is no significant effect of self-regulation process on secondary school students' interest in quantitative chemical analysis, $p < .05$.

**Method**

A quasi experimental pretest-posttest control group design was used for the study. The population comprised Senior Secondary Chemistry Class III (SS III) students offering chemistry in Orlu Education Zone, Imo State. The sample for the study was made up of 284 SS III chemistry students from two male and two female only schools from the zone. Two intact classes for each of two groups were randomly drawn and assigned experimental and control groups. Treatment and control groups were randomly assigned to different classes in the same school. The treatment group exposed to self-regulation was 148 (71 boys and 77 girls). To obtain equal replication of subjects, simple random sampling was used to select the responses of 71 girls for treatment and control groups respectively (equal replication in a 2 x 2 ANCOVA allows for the estimation of experimental error).

Instrument used for data analysis was Quantitative Chemical Analysis Interest (QCAIS). It was a 26-item Likert type responses ranging from strongly agree (SA), agree (A), disagree (D) and strongly disagree (SD). The instrument was validated by five experts in science education and two chemistry teachers from secondary schools. The reliability coefficient was determined to be 0.67.
During the data collection phase of the study which was conducted in three sessions (double periods) of 80 minutes each, the two groups were taught the concepts of neutralisation, indicators and titration procedures. (calculations in quantitative chemical analysis followed but excluded in the sample lesson plan given here.) The students in the experimental group were exposed to activities organised in five stages.

**Phase 1: Engagement –** Since self-regulation encourages students' participation, the indicator used was extracted from hibiscus flower by the students themselves. It was grounded in a mortar, mixed with ethanol and water, and the mixture vaporised. The base used was extracted by the students from dried palm bunch which was burnt in a clean local calabash (*oku*). Solution was made and filtered. This activity provides meaningful experience as students use materials from their environment at low cost.

**Phase 2: Exploration –** The students were supplied with 0.1M $H_2SO_4$, test tubes, burettes, pipettes and conical flasks. The concept of neutralisation was introduced using the following questions:

a. How would the potash filtrate react with 0.1M $H_2SO_4$? Name the reaction.
b. Identify when the reaction has reached completion. (use test tube.) Hibiscus flower extract could be used to detect this? How?
c. What function does hibiscus flower extract serve?
d. Now pour the acid in the burette and the caustic potash filtrate in the pipette. Adjust to $50cm^3/25cm^3$ respectively.
e. What omissions/activities would result to inaccurate data?

This is a teacher-guided inquiry meant to illicit active responses from students based on their prior knowledge.

**Phase 3: Explanation –** Students collaboratively discussed the concepts of indicators, neutralisation and titration. The teacher may elaborate on their conceptual understanding. He may also ask students the following questions: Is it possible to carry out the same experiment using unripe citrus fruit juice, vinegar; the teacher may now highlight the indicators used for titration between strong acid vs. strong base; strong acid vs. weak base; weak acid vs. weak base.

**Phase 4: Elaboration –** With the above activities, students converged in their discussion groups (of fours) to discuss the following:

a. What colour change did you observe on using different indicators on various strengths of acids and bases?
b. The fact that substances obtained from the environment which is used for domestic purposes could also be used for titration.
c. Other types of acid-base titration and appropriate indicators.

This stage encourages cooperative learning which may result to: reduced level of stress; promotion of more positive attitudes; more transfer of what was learned earlier; enhancement of reasoning and critical thinking skills among peer groups.

**Phase 5: Evaluation –** The following questions may guide the students and the facilitator (teacher) to evaluate the lesson:

a. What happened when neutralisation reaction reached completion?
b. What is the concept or term given to that end point?
c. Mention the use of flower pigments.
d. Carry out the same exercise at home using the potash filtrate and lime juice.
e. Poison prevention is an important issue in storing caustic materials in the home. Mention some household items that are caustic in nature. Attempt to find out their chemical formulae and test their reaction with acidic items in nature. Thus, determine the chemical equation of the reactions.

This process of evaluation is a self-regulatory approach involving higher order skills e.g. application.
Students in traditional group were taught neutralisation, indicators and titration by lecture method. The titration procedure was demonstrated by the teacher using standardised 0.05M KOH and 0.1M $H_2SO_4$ and screened methyl orange indicator. The students were then supplied with titration apparatus to carry out the experiment while the teacher supervised.

**Results of Data Analysis**

Table 1: Analysis of Covariance (ANCOVA) of students' interest scores (by gender by teaching method)

| Source of Variation | Sum of Squares | Degrees of Freedom (df) | Mean Square | Significant at F | Decision at 0.05 Level |
|---|---|---|---|---|---|
| Covariance (Pre-treatment) | 16.98 | 1 | 16.98 | .00 | S |
| Main effects | 43.99 | 3 | 14.60 | .00 | |
| Teaching Method | 2.72 | 1 | 2.72 | .00 | |
| Gender | 1.95 | 1 | 1.95 | .00 | S |
| Teaching method and Gender | 4.94 | 1 | 4.94 | .00 | S |
| Explained | 48.93 | 4 | 12.23 | .00 | |
| Residual | 22.77 | | .082 | .00 | |
| Total | 71 | 283 | | | |

**Discussion of Findings**

Table 1 shows that teaching method as main effect was significant on the interest of students in quantitative chemical analysis. This is because as shown in the table, teaching method as main effect is significant at F value of .00. Therefore, at a higher F value of .05 teaching method as main effect is significant. This leads to the rejection of null hypothesis of no significant difference between mean interest score of students taught through the process of self-regulation and those taught using traditional method. This confirms that self-regulation enhanced the interest of students in the experimental group more than the students in the traditional group.

The result agrees with Hasan (1975) who investigated the influence of some selected variables including instruction on the development of students' interest in science. He found that certain instructional methods are important in the development of science interest among secondary school students.

The stages used in the process of self-regulation were meant to actively involve learners as well as create environment in which equilibrium can occur in the minds of learners. Local materials used were meant to capture the interest of students and to help them link materials in their environment with laboratory activities in the classroom.

**Conclusion**

Students' active participation and metacognition of the practical work accounted for the significant effect on their interest in quantitative chemical analysis. One of the goals of self-regulation process is to excite students by creating opportunities for them to 'do' science. Self-regulation process challenges students to develop higher order cognitive skills as against conventional procedures. Hence, the questions posed at the various stages were meant to challenge the students into brainstorming. Thus, the students were capable of applying the knowledge gained to relevant situations at home. Self-regulation process was expected to sustain the interest of students in quantitative chemical analysis and to enable them develop creative thinking, problem-solving ability and 'soft skills' through the process skills involved in quantitative chemical analysis. In transferring the ownership of learning to the learner in self-regulation students brought their own ability into play. In addition, they were able to develop innovative practices such as producing indicator from hibiscus flower and alkaline from potash bunch.

**Educational Implications**

Since self-regulation in science presupposes that learners take responsibility for the learning process, it therefore encourages students to take appropriate decisions in the learning process. This is an integral part of sustainable education. To train students to become self-regulated learners, teachers self-efficacy and professional development in self-regulation is very important.

Curriculum planners are encouraged to employ the skills of self-regulation in designing chemistry curriculum. To make chemistry teaching and learning interesting, teachers should structure their lessons to make classroom teaching relevant to them within the society. Acting as facilitators, teachers are urged to ginger students (male and female) to active participation and to promote social skills through classroom interaction. Time has come when students should be helped to develop 'soft skills' from the classroom if sustainable science education must be achieved by 20:20:20.

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