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# Motivating Students to Learn Chemistry by Programmed Instruction: The case of Kenyan Secondary Schools

**Masinde Joseph Wangila***
Chemistry Educator, Mount Kenya University & Shiraha Secondary School, P.O. Box 68 - 50101, Butere, Kenya

***Corresponding Author:**
Masinde Joseph Wangila
Email: jossemasinde@yahoo.com

**Abstract:** This study investigated how students' motivation in Chemistry is affected through the use of Programmed Instruction in abstract topics. The research location was Butere sub-county, Kakamega County, Kenya. Quasi-experimental research design was used to implement the study, using Solomon four-group as a model. A group of 300 form two students, who were purposively sampled from a target population of 841 students, was used. Those who were assigned into experimental groups received their instruction using Programmed Learning Software, while their counterparts in control groups were taught conventionally. Focus was on the topic "structure of the atom and the periodic table" because it is abstract in nature and many students perform dismally in it during national examinations. The Students' Motivational Level Determination Questionnaire (SMLDQ) was designed by the researcher and assessed for its validity and reliability, then used to collect raw data, which was analyzed both descriptively (using mean and standard deviation) and inferentially using one-way ANOVA at α=0.05. Results revealed that Programmed Instruction was superior to the conventional approaches because the sampled students' pre-test motivation scores were statistically similar ($M_{E2}$=56.8, SD=14.2, $M_{C1}$=53.7, SD=14.8, t(299)=-4.13, p=.272] but significantly different in the post-test, in favour of the experimental groups [$M_{E1}$=66.8, SD=11.9, $M_{E2}$=66.8, SD=13.8, $M_{C1}$=56.0, SD=16.3, $M_{C2}$*=56.3, SD=14.9, F(3,296)=15.8, p<.001*]. These findings have instructional implications in science education.
**Keywords:** Programmed Instruction, Conventional Instruction, Motivation.

## INTRODUCTION

Chemistry education in most secondary schools around the world aims at motivating learners to gain interest towards appreciating the importance of scientific work in real life and as a result, most countries, through their relevant ministries of education, put a lot of emphasis on its importance by investing heavily in science education [1]. In Kenya, this happens through the Science and Technology Innovations Programme, which rewards handsomely students who come up with technological solutions to real life problems [2].

One of the current leading challenges facing Chemistry education in Kenya currently is students' poor performance in the subject, which has been the case for the last 10 consecutive years [1]. Students' low motivation in abstract topics due to teachers' use non-student centred instructional methods is the reason that has been given to account for this situation [3]. Research reveals however that the use of Programmed Instruction (PI) plays a crucial role in enhancing students' motivation in a subject, when used alongside the conventional methods of instruction [4]. Not all topics in Chemistry are performed dismally though, because question-by-question analysis of past Kenya Certificate of Secondary Education results in Chemistry reveal that only topics that are abstract in nature are most affected [5]. One such topic is Structure of the Atom and the Periodic Table (SAPT), which is taught in form two. The Kenyan Chemistry curriculum specifies that by the end of this topic, the learner should be able to; (i) draw the structure of an atom and describe its properties, (ii) carry out simple calculations about relative atomic mass, atomic and mass numbers, (iii) write electron configurations of the first 20 elements, (iv) draw a simplified version of the periodic table and explain the position of an element therein, (v) distinguish between valency and oxidation number, (vi) write chemical formulae of simple compounds and radicals, then (vii) write simple and well balanced chemical equations [1, 6]. Most of these concepts are abstract in nature and therefore the use of a good student-centred instructional method would play the all-important role of motivating students to learn them, which should consequently result in improved performance in the subject during national examinations, or so the researcher believes.

Programmed Instruction will be explored in this study, to teach the form two topic of SAPT. This is an approach to learning where a leaner is presented with material in small chunks, in logical sequence, where he or she must be successful in one concept before they can move on to the next [7]. This method has been found very effective in the sense that it is totally student-centred, unlike the Conventional Methods of Instruction (CMI), and students learn at their own rate, with immediate feedback [1]. Its use in the structure of the atom and the periodic table is therefore a long overdue alternative to the CMI, because there is no Kenyan study known to the researcher so far, that has investigated how effective it is in enhancing students' motivation in the country, hence the study.

On the global front, a number of studies have been done concerning PI and how it affects students' motivation, but conflicting findings continue to emerge. A very recent study, by Chiang & Jacobs examined the effectiveness of programmed instruction the motivation of high school students to read. Students in their experimental groups received training on the Kurzwell 3000, programmed instruction software, and used it to do their homework for a period of 10 weeks. Their control group on the other hand used paper and pencil. The Scholastic Reading Inventory (SRI) was used to collect data, which was used to compare changes in motivation before and after intervention. Results of their study suggested that the instructional software had a significant impact on students' motivation to read. These findings seem to corroborate Johnson & Stannes' [8] findings, whose study investigated the effects of computer based teaching in co-operative interactions and motivation. The latter found that students in computer based co-operative treatment showed higher motivation to accomplish learning goals than those in competitive and individualistic treatments. These and other studies seem to point out the fact that group-oriented PI might be a more appropriate way to account for human context factors.

Studies have also indicated that; (i) learners in small group and/or co-operative situations tend to use each other as resources more often than in other learning situations; (ii) a combination of group and individual awards resulted in peer tutoring [9]. A much older study by Allesi & Trollip [10] asserted that computer based programmed instructions are beneficial in motivating secondary school students in areas where they have lost interest. This notion is supported by other studies that have all suggested that PI software could greatly improve learning and student motivation towards the subject [11, 12]. Further review of related literature indicates that programmed instruction can also improve students' satisfaction and help sustain their interest in Mathematics and related subjects. A good example is a study on PI, in which paired students learned new concepts through computer-assisted lessons. The study revealed that; (i) paired students choose elaborative feedback more frequently than did those who worked alone on the computer; (ii) students in co-operative situations appeared to motivate each other to seek elaborative feedback in their responses to practice items [1, 13]. These findings are however in contrast with those of another study by Johnson & Stannes [8] whose findings on the effects of PI in co-operative interactions and motivation reported that students in the PI treatment groups showed no significantly different motivational levels from those in competitive and individualistic treatments.

The specific objective of this study was to find out if there is any difference in motivation between students who are taught Chemistry using Programmed Instruction and those who are taught the conventional way. The null hypothesis ($H_o$) formulated from this objective was, "There is no difference in motivation between students who are taught Chemistry using Programmed Instruction and those who are taught the conventional way", which was tested statistically at the 95% confidence level.

## MATERIALS AND METHODS

This study adopted a quasi-experimental research design, using the non-randomized Solomon four-group as a model. This particular design was chosen because the units of sampling i.e. form two classes were already constituted, and it was therefore unethical to randomly select the required participants as required in experimental researches (Pearl, 2015). However, the selected classes were randomly assigned into experimental (E1 and E2) and control (C1 and C2) groups. Groups E2 and C1 received both pre-test and post-test, while groups E1 and C2 only received post-test, as stipulated in the Solomon four design. E1 and E2 were taught the SAPT using programmed instruction, while C1 and C2 were taught the same using the conventional methods of instruction. This research design controlled for interaction, a potential threat to the study's internal validity by using different schools as experimental and control groups. Selection on the other hand is a threat that was dealt with by purposively sampling schools of the same academic calibre by basing on previous performance in the Kenya Certificate of Secondary Education examinations.

Purposive sampling technique was used to select four mixed (co-educational) secondary schools in the reach area, which was Butere sub county, Kakamega County, in Kenya, which have computer laboratories. This approach was achieved by using the list of schools that offer computer studies within the county as the sampling frame. The researcher was only interested in schools that have computer laboratories because instructional software that was used in the treatment groups of this study needed many computers, all in one room. In Kenya, only schools with computer laboratories are allowed by the Ministry of Education to offer computer studies, hence the purposive sampling. Mixed schools were used in order to take care of gender as an extraneous factor. Butere Sub County on the other hand was selected because it is one of the regions in the country, whose schools perform very poorly in national examinations, especially in Chemistry. Form two students were used because the topic under investigation, which was structure of the atom and the periodic table, is found at this level the syllabus. A total of 300 students and 8 teachers were used. This number was arrived at basing on the Krejcie and Morgan formula. The four selected groups were not equal in size because form two classes that had to be selected were already constituted.

Raw data was collected using the Students' Motivational Level Determination Questionnaire (SMLDQ). This was a close-ended questionnaire, with 20 items which were on a five point likert-type scale. Some of the statements therein were favourable and others unfavourable, which were all designed basing on some of the Keller's (2010) motivational variables, shown in Table 1.

**Table 1: Motivation Variables in the SMLDQ**

| VARIABLE | DESCRIPTION |
|---|---|
| Attention | Extent to which the students feel Chemistry arouses their attention in class. |
| Confidence | The extent to which Chemistry content boosts students' confidence |
| Satisfactory | Extent to which students feel Chemistry will satisfy their future needs |
| Relevance | Extent to which Chemistry content is important in students' future careers |

Adapted from: Keller [14]

Favourable statements in the SMLDQ were scored in descending order i.e. strongly Agree=5, Agree=4, Undecided=3, Disagree=2 and Strongly Disagree=1, while unfavourable statements therein were scored in the reverse order. To enhance completion rate, the researcher produced coloured copies of the SMLDQ. Return rate on the other hand was enhanced by providing each respondent with a blank study timetable, with examination preparation tips on it, as a non-monetary incentive. The SMLDQ was validated using two educational research experts, who were requested to critique all items in it. Their comments were used to modify the instrument, which made it more suitable for data collection during the actual study. Its reliability was assessed using the Cronbach's alpha coefficients for internal consistency. A coefficient of 0.764 was obtained, which implies that this instrument, if used again under similar conditions would produce similar results. This assertion is deduced from the fact that the co-efficient obtained was above the minimum recommended value of 0.7 for educational researches [15].

The Programmed Learning software that was used by students in the experimental groups of this study was developed by the researcher, with help from a software engineer. Before being used, the software was validated using experts from the Kenya Institute of Curriculum Development (KICD), who gave it a clean bill of health. The software was installed on all computers in schools that were assigned to the experimental groups, and was used for teaching and learning of the SAPT. Content in the topic of structure of the atom and the periodic table was placed on 10 frames, in sequential order, such that a student had to correctly answer a question at the tail end of a subtopic before the 'proceed to the next" button on the computer screen could become active. Students who could not get correct answers were referred by the programme to a subsidiary frame, which had more examples and explanations in simpler language. The role of Chemistry teachers was to introduce the topic using conventional instructional methods and to summarize the topic when students were through with all the content. Teachers also helped students who had difficulty using the software during initial stages of the topic.

Research assistants were trained beforehand by the researcher on how administer the SMLDQ as per the research design. Groups E2 and C1 were first given the pre-test SMLDQ, followed by intervention that lasted for four weeks. The post-test SMLDQ was thereafter administered to all the four groups. The completed questionnaires were coded in SPSS to facilitate analysis. Data collected was first analyzed descriptively by computing the mean, mean gain and standard deviation of each research group, then inferentially using independent samples t-test and one-way Analysis Of Variance (ANOVA) for pre-test and post-test respectively. Both analyses were done at $\alpha=0.05$, to determine if the motivation mean scores of the groups under comparison differed significantly from each other before and after intervention. One-way ANOVA was used because there were more than three groups in the post-test, classified basing on one factor (group type). Independent samples t-test was used because in the pre-test, there were only two groups being compared, which were not related in any way. Assumptions of these two parametric tests were assessed beforehand; normality of the motivation scores was assessed using the Shapiro-Wilk test, while homogeneity of variances of the scores was assessed using Le Verne's test. Both tests yielded non-significant p-values, implying that the data was fit for analysis, using these two parametric tests. Independence of the research groups was not assessed because it had already been taken care of by the research design, in the sense that only intact classes were selected and used for the study, meaning that no student stood the chance of belonging to more than one research group.

## RESULTS AND DISCUSSION

Results of descriptive analysis of the sampled students' motivation scores before and after intervention were as presented in Table 2.

An examination of Table 2 reveals a margin of 3.1 marks in the pre-test motivation mean scores between experimental group E2 and control group C1. However in the post-test, the Table reveals that the margin between mean scores of the same groups increased fourfold to 12.6 marks, with E2 outperforming C1. In the same post test, the mean scores of E1 and C2, both of which were not pretested had a margin of 10.5, which is comparable to the margin between the mean scores of the pretested groups. This implies that the pre-test did not affect the outcome of this study, as far as the study's objective is concerned, which is also a good pointer that the threats to internal consistency were effectively countered.

**Table 2: Means and standard deviations of students' motivation scores**

| **Group** | **Pre-test** | | **Post-test** | | **Mean Gain** |
|---|---|---|---|---|---|
| | **Mean** | **Std. Dev.** | **Mean** | **Std. Dev.** | |
| **E1 (N=76)** | - | - | 66.8 | 11.9 | - |
| **E2 (N=74)** | 56.8 | 14.2 | 68.9 | 13.8 | 12.1 |
| **C1 (N=72)** | 53.7 | 14.8 | 56.0 | 16.3 | 2.30 |
| **C2 (N=78)** | - | - | 56.3 | 14.9 | - |
| **Whole sample** | 55.3 | 14.5 | 61.5 | 14.7 | 6.2 |

Post-test mean scores of the experimental groups E1 and E2 (66.8 and 66.9 respectively) were apparently superior to those of the control groups C1 and C2 (56.0 and 56.3 respectively). Table 2 further points out that while the mean gain of the entire sample was 6.2, that of the pretested groups E2 and C1 were 12.1 and 2.30 respectively, which shows that the experimental group had a greater improvement in academic motivation than the control group.

To establish if the selected students were statistically at the same level of motivation at the initial stage of the quasi experiment, independent samples t-test was used to compare the pre-test mean scores of the experimental and control groups, whose results were as shown in Table 3.

**Table 3: Independent samples t-test on pre-test motivation scores**

| | | Levene's Test for Equality of Variances | | | | |
|---|---|---|---|---|---|---|
| | | F | Sig. | T | df | Sig. (2-tailed) |
| Score | Equal variances assumed | 5.157 | .272 | -4.13 | 299 | .156 |
| | Equal variances not assumed | | | -4.13 | 299 | .156 |

As the Table reveals, there was no statistically significant difference in pre-test motivation scores of students in the control and experimental groups [t (299) = -4.13, p = .272 at α = .05] since the p-value obtained is greater than the stipulated alpha level. This therefore implies that the sampled students were at the same level with respect to motivation in Chemistry before intervention.

To establish whether or not the students' motivational level differed after intervention, one-way ANOVA was performed on the students' post-test motivation scores. Results of this inferential test were as presented in Table 4.

**Table 4: One-way ANOVA on post-test motivation scores**

| **SOURCE** | **d.f** | **SS** | **MS** | **F** | **p** |
|---|---|---|---|---|---|
| Between groups | 3 | 10, 257.106 | 3, 419.035 | 15.844* | 0.000 |
| Within groups | 296 | 63, 876.661 | 215.800 | | |
| TOTAL | 299 | 74,133.767 | - | | |

*Significant at α = 0.05

As Table 4 indicates, there was a statistically significant difference in the post-test mean scores of the four groups [F (3, 296) = 15.8, p < .001 at α = .05]. This is because the p-value obtained is less than the specified alpha level. This output implies that the mean of at least one of the four groups significantly differed from the rest. However, to find out exactly which group(s) significantly differed from others, post hoc testing was mandatory, which was done and its results were as shown in Table 5.

**Table 5: LSD post hoc test p-values for post-test motivation scores**

| | E1 | E2 | C1 | C2 |
|---|---|---|---|---|
| E1 | - | 0.973 | 0.009* | 0.001* |
| E2 | 0.973 | - | 0.02* | 0.004* |
| C1 | 0.009* | 0.02* | - | 0.876 |
| C2 | 0.001* | 0.004* | 0.876 | - |

*significant at α=0.05

The Table reveals that motivation mean scores of experimental groups (E1 and E2) did not significantly differ and so was the case with control groups (C1 and C2). Table 5 further reveals that mean scores of the experimental groups significantly differed from the control groups. This result, when interpreted together with that yielded from the earlier presented descriptive statistics clearly suggest that the experimental groups were superior to control groups, with regard to post-test motivation scores.

The null hypothesis ($H_o$) of this study as earlier stated was, "there is no difference in motivation between students who are taught the Structure of the Atom and the Periodic Table using Programmed Instruction and those who are taught using the Conventional Methods of Instruction". The study however found a statistically significant f-ratio on the four post-test motivation mean scores, which is contrary to the Ho. The null hypothesis was therefore rejected because the empirical evidence arising from both descriptive and inferential statistics of this study suggest otherwise.

It can now be asserted from these findings that using programmed instruction in the SAPT improves motivation of students in the topic, when compared to using the CMI. This is because the sampled students had statistically the same motivation level before PI was introduced. The change in motivation level is therefore attributed by the researcher to treatment that the experimental groups received. These findings are in unison with those of Iserameiya & Anyasi [7] whose Nigerian study found out that the use of programmed instruction was effective on students' academic motivation and also promotes learners' active participation in a subject. Another study by Alaba *et al.;* [16] on the effects of computer-assisted programmed instruction on students' learning outcomes in typewriting also concurs with findings of this study, as it revealed that 97.6% of the students that were interviewed in that study agreed that programmed instruction's mode of feedback improved their understanding in typewriting because they had an opportunity to repeat given tasks until satisfactory attempt was made.

## CONCLUSION

On the basis of data collected in this study and the empirical evidence provided by the study's statistical analyses, it has been concluded that the use of programmed instruction in the SAPT significantly improves students' motivation in the topic when compared to the CMI. This positive impact of PI on students' motivation is attributed to the fact that it was totally student-centred, and provided immediate feedback to the learners on whether they had correctly understood concepts in the topic or not. Teachers of Chemistry around the world, especially those in Kenya, should therefore embrace it fully, especially in abstract topics, so as to solve the current performance crisis plaguing Chemistry education in the country.

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