Effects of Science Process Skills Mastery Learning Approach on Students’ Acquisition of Selected Chemistry Practical Skills in School

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The study investigated the effectiveness of Science Process Skills Mastery Learning Approach (SPROSMALEA) on students’ acquisition of Chemistry practical skills. The Solomon Four Group, Non-equivalent Control Group Design was employed in the study. The study was carried out in Koibatek District, Kenya where there has been persistent low achievement in the subject. 160 form two students from four co-educational schools, purposively selected from the District were taught the same course content on salts for a period of four weeks. The experimental group received their instructions through use of SPROSMALEA approach and control groups using the conventional teaching method. The researcher trained the teachers in the experimental groups on the technique of SPROSMALEA before the treatment. Science Process Skills Performance Test (SPSPT) and Classroom Observation Schedule (COS) were used for data collection. The results of the study indicated that students in the experimental groups outperformed the control groups in the acquisition of selected Chemistry practical skills. It was concluded that SPROSMALEA enhanced better performance in Chemistry than the conventional teaching method. Chemistry teachers should be encouraged to incorporate this method in teaching and should be included in regular in-serving of teachers in Kenya.

Keywords: Science Process Mastery Learning Approach (SPROSMALEA); Acquisition of Selected Chemistry Practical Skills; Conventional Teaching Method

Introduction

The word science is a noun derived from a latin term “scientia” meaning knowledge (Ross, 2000). According to Ross, science is a process or way of arriving at a solution to a problem or understanding an event in nature that involves testing a possible solution. Effective science learning depends on the method and techniques employed by the teachers during instructional process (Das, 1985). Students learn science best when the teaching methodology enables them to get involved actively in class activities. They should participate actively in doing experiments, carrying out demonstrations, class discussion and other relevant learning experience. Ajaja (2007) identified the objectives of teaching science to include 1) Knowledge of science academic discipline 2) To acquire the skills of scientific method 3) Having clear explanations for societal issues through increasing interest in science literacy and societal goal 4) For personal needs 5) For career awareness. If students actively engage in Science processes they can come to recognize that scientific knowledge is based on experiments in which meaning of data is negotiated and theories are not absolute. Knowledge in this context consists of learning experimental methods and the norms and practices of scientific communities as much as it does learning known facts and correct theories within a domain (Wheeler, 2000).

Chemistry occupies a central position amongst the science subjects. It’s a core subject for medical science, textile technology, agricultural sciences, chemical engineering. According to Ohodo (2005), Chemistry contributes generating to the attainment of the aims of education and specifically helps individuals to develop effective process skills, critical thinking and competencies required for dealing with observation, classification, inferences, experimentation and interpretation of data and generalization.

SPROSMALEA is an Acronym got by integrating existing science process skills and mastery learning methods. It was an approach used in teaching the experimental groups in this study to see whether it improved in the acquisition of Chemistry practical skills.

The study aim at finding the effect of SPROSMALEA on students’ acquisition of selected Chemistry practical skills. This approach is an integration of existing Science Process Skills and Mastery Learning in an effort to come up with a new approach (SPROSMALEA). This method of teaching had not been tried out in Chemistry teaching and learning in Koibatek District, Kenya where performance in the subject had continued to decline.

Research Hypothesis

The purpose of the study was to determine the effects of Science Process Skills Mastery Learning Approach (SPROSMALEA) on Students’ acquisition of selected Chemistry practical skills.

The following null hypothesis was tested in this study at significance alpha level of .05.
Research Design

The study used Solomon Four Non-equivalent Control Group Design. This is because there was non-random selection of students to the groups. Secondary school classes exist as intact groups and school authorities do not normally allow the classes to be dismantled and constituted for research purposes (Fraenkel & Wallen, 2000).

Four groups of participants, the Experimental Group One (E₁), Experimental Group Two (E₂), Control Group One (C₁) and Control Group Two (C₂) was used. Groups E₁ and E₂ formed the experimental groups which received treatments (SPROSMALEA) while C₁ and C₂ were the control groups that did not receive the treatment. Groups E₁ and C₁ received pre-test while E₂ and C₂ did not. All groups received the post test at the end of the course. To avoid interaction of students from different groups that may contaminate the results of the study, one class from a school constituted one group of subjects, hence four schools were required for this study. The selected classes were randomly assigned to the experimental and control groups (Mugenda & Mugenda, 2003; Borg & Gall, 1989; Mutai, 2000).

Sample

The actual sample size that participated was 160 form two students, selected using purposive sampling method from 4-co-educational schools which met the requirements (having laboratories apparatus, qualified science teachers and could easily be accessed using the Nakuru-Eldama Ravine road), situated in Koibatek District, Kenya (Table 1).

Development and Use of Teaching Materials

The content to be used in the class instruction was developed and based on the revised KIE 2002 chemistry syllabus, teachers guide, students textbook and other relevant materials. Teachers’ manuals included the content to be covered and lesson plans to be used in teaching topic salts in form two chemistry. Student manuals were the worksheets including the guidelines and procedures the learners would use when performing experiments in the laboratory. These manuals were only used in the experimental groups. The teacher had to mention the expected objectives the learner had to achieve at the end of the lesson, introduced the lesson, discussed the results of the experiment, give assignments and remedial to those learners who had not mastered the concepts and skills. In control groups, the conventional teaching method was used. The teachers in the experimental groups were trained in the new approach, given teaching modules and student manuals by the researcher. Classes in all the four groups used the same curriculum materials and spent about the same time four weeks on topic salts as recommended in the syllabus.

Table 1.
Sample size of the study.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Number of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>E₁</td>
<td>38</td>
</tr>
<tr>
<td>E₂</td>
<td>39</td>
</tr>
<tr>
<td>C₁</td>
<td>46</td>
</tr>
<tr>
<td>C₂</td>
<td>37</td>
</tr>
<tr>
<td>Total</td>
<td>160</td>
</tr>
</tbody>
</table>

Ho₁: There is no statistically significant difference in acquisition of selected Chemistry practical skills, experimenting, observation and inferences between students who are exposed to SPROSMALEA and those who are not.

Instrumentation

Two instruments were used to collect the data:
1) Science process skills performance test SPSPT.
2) Classroom observation schedule.

Science Process Skills Programme Test (SPSPT)

Science Process Skill Performance Test (SPSPT) was used to evaluate the performance of process skills (experimenting, observation and inferences) by the student. It contained two practical items on salts. This instrument was pilot tested in two schools with a similar characteristic in Koibatek District, but did not take part in the study. The reliability was estimated using K-R 21 and a reliability of .88. The reliability coefficient level is above .7, hence acceptable. This implied that there was a good internal constituency of items (Frankel & Wallen, 2000).

Classroom Observation Schedule

COS was used to observe four lessons on the topic salt to provide data on teacher and students activities during instruction processes. It had two sections which provided data on the teachers and students activities respectively. It contained eleven teachers and students related items. The instruments pilot tested in two schools in Koibatek District, not included in the study. Sixteen items were used in the calculation of Cronbach’s Alpha (α) for the test of how reliable the student activity was and Cronbach’s alpha .97 was obtained. In the teacher’s activities eleven observations were used in the calculation of the Cronbach’s alpha (α). Cronbach’s alpha coefficient of .93 was obtained. Both items had a high reliability coefficient hence acceptable since alpha was above .7 (Frankel & Wallen, 2000).

Data Collection Procedure

The students in the study were randomly assigned into the four groups experimental group I (E₁), experimental group II, control group I (C₁) and control group II (C₂). A pre-test was conducted in one experimental group (E₁) and one control group (C₁) in order to measure the students entry behaviour before the treatment. In experimental groups E₁ and E₂ SPROSMALEA was used while in control groups C₁ and C₂ conventional teaching method was used. At the end of the treatment period the post test (SPSPT) was administered to all groups. The researcher supervised the teaching and scored the pre-test and post-test. COS was used to provide data in the teachers and students activities. Data was collected from at least four lessons taken from each of the experimental and control groups. The frequency of the class activities observed in the study was calculated as means roupas.

Results and Discussion

SPSPT was used to pre-test for the two groups, experimental
The results in Table 2 revealed that the difference in students scores in the SPSPT were not statistically significant \( t(82) = 1.48, P > .05 \). This indicates that the groups used in the study exhibited comparable characteristics and therefore suitable for the study.

**Effects of SPROSMALEA on Students Acquisition of Selected Chemistry Practical Skills (SPSPT)**

The hypothesis of the study sought to find out whether there was any statistically significant difference in scores in the acquisition of science process skills (experimenting, observation and inferences) between students who were exposed to SPROSMALEA and those who were not. Table 3 shows (SPSPT) post-test mean score obtained.

Results in Table 3 shows that the mean scores obtained by students in E1, group (M = 36.41) and C1 group (M = 39.11) before the commencement of treatment. The difference in mean scores were not statistically significant (Table 2). But after the treatment the student who were exposed to SPROSMALEA (E1 and E2) outscored the control groups. E1 group scored higher mean (M = 58.15) than C1 group (M = 53.24). Also the mean gain for E1(21.74) was higher than that of the whole groups (18.08) and for the C1(14.13). This shows that the use of SPROSMALEA enhanced the performance than the use of conventional method.

Table 4 indicates that a statistically significance difference exists between mean scores of the groups F(3,155) = 6.38, \( P < .05 \). The null hypothesis could be rejected but the findings could not indicate where the difference was. It was necessary to carryout, Least Significant Difference (LSD) post hoc comparisons, to know which groups were statistically significant different.

Table 5 shows the results of post hoc comparisons test of significance for a difference between two means. The SPSPT means of groups E1 and C1, groups E1 and C2, groups E2 and C1, groups E2 and C2 were statistically significant different at .05 level.

However there was no statistically significant difference in the means between groups E1 and E2 groups C1 and C2. From this, the students in the experimental conditions outperformed students in the control groups. It can therefore be concluded that SPROSMALEA approach used by experimental groups led to a relatively higher acquisition of practical skills (experiment, observation and inferences in the learning of salts, than those who used the conventional method.

Since the study involved non-equivalent control group design, there was need to confirm there results by performing analysis of covariance (ANCOVA) using students Kenya Certificate of Primary Education (KCPE) scores as covariate.

Analysis of covariance reduces the effects of initial group differences statistically by making compensating adjustments to the post-test means of the groups involved (Borg & Gall, 1989; Wachanga, 2002).

Table 7 shows ANCOVA results based on the adjusted means of the four groups displayed in Table 6. There is statistically significant difference in the SPSPT mean score of the four groups. \( F(3,154) = 6.12, P < .05 \). P value is less than .05.

The post hoc pairwise comparison based on ANCOVA Table 8, shows that there is a statistically significant difference in the following groups.

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### Table 2.

Independent sample t-test of the pre-test scores on SPSPT.

<table>
<thead>
<tr>
<th>TEST GROUP</th>
<th>MEAN</th>
<th>SD</th>
<th>t-value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPSPT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E1</td>
<td>36.41</td>
<td>13.22</td>
<td>.95</td>
<td>.34</td>
</tr>
<tr>
<td>C1</td>
<td>39.11</td>
<td>12.89</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Mean difference not significant at .05.

### Table 3.

Comparison of means, standard deviations (S.D) and mean gain obtained by the student on the SPSPT.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Overall</th>
<th>E1</th>
<th>C1</th>
<th>E2</th>
<th>C2</th>
<th>E1-C1</th>
<th>E2-C2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-test mean</td>
<td>37.76</td>
<td>36.41</td>
<td>39.11</td>
<td>39.11</td>
<td>39.11</td>
<td>4.38</td>
<td></td>
</tr>
<tr>
<td>S.D</td>
<td>13.06</td>
<td>13.22</td>
<td>12.89</td>
<td>12.89</td>
<td>12.89</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-test mean</td>
<td>55.84</td>
<td>58.15</td>
<td>53.24</td>
<td>60.58</td>
<td>51.81</td>
<td>7.34</td>
<td>6.77</td>
</tr>
<tr>
<td>S.D</td>
<td>9.99</td>
<td>12.89</td>
<td>10.22</td>
<td>7.54</td>
<td>9.31</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main gain</td>
<td>18.08</td>
<td>21.74</td>
<td>14.13</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 4.

ANOVA of the post-test scores on the SPSPT.

<table>
<thead>
<tr>
<th>Test</th>
<th>Group</th>
<th>SS</th>
<th>DF</th>
<th>Mean square</th>
<th>F</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPSPT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>1960.39</td>
<td>3</td>
<td>656.46</td>
<td>6.38</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>within groups</td>
<td>15956.36</td>
<td>155</td>
<td>102.94</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17925.75</td>
<td>158</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Mean difference is significant at .05 level.

### Table 5.

Post hoc comparisons of SPSPT post-test means for four groups.

<table>
<thead>
<tr>
<th>I Group</th>
<th>J Group</th>
<th>Mean differences (I-J)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>C1</td>
<td>–2.42</td>
<td>.30 (NS)</td>
</tr>
<tr>
<td>C2</td>
<td>E1</td>
<td>–6.35</td>
<td>.01</td>
</tr>
<tr>
<td>E2</td>
<td>C1</td>
<td>–7.34</td>
<td>.00</td>
</tr>
<tr>
<td>C2</td>
<td>E2</td>
<td>–4.92</td>
<td>.00</td>
</tr>
</tbody>
</table>

Note: *Significant at \( P < .05 \). (NS) = Not Significant.

### Table 6.

Adjusted SPSPT post-test mean scores for ANCOVA with KCPE scores as covariate.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>38</td>
<td>58.16</td>
</tr>
<tr>
<td>E2</td>
<td>39</td>
<td>60.58</td>
</tr>
<tr>
<td>C1</td>
<td>46</td>
<td>53.18</td>
</tr>
<tr>
<td>C2</td>
<td>37</td>
<td>51.94</td>
</tr>
</tbody>
</table>

### Table 7.

Analysis of covariance (ANCOVA) of the post-test score of SPSPT with KCPE.

<table>
<thead>
<tr>
<th>Sum of square</th>
<th>DF</th>
<th>Mean squares</th>
<th>F</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>KCPE</td>
<td>32.07</td>
<td>.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td>1537.62</td>
<td>32.07</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>102.46</td>
<td>6.12</td>
<td>.00</td>
<td></td>
</tr>
</tbody>
</table>

Note: *F = 6.122, DF = 3, P < .05. Mean difference is significant at .05 level.*
activities in the experimental group were 63.25 and 73.05 while control groups (C 1 and C 2). The total mean scores of teacher students did more activities than the teachers. This is evident by the means of students of 85.5, 83.25, 45.25 and 59.25, teacher students in the control group were 51.25 and 36.5. In experimental, the means of students of 85.5, 83.25, 45.25 and 59.25, teacher groups.

1. Reinforce appropriate response 6.90 9.50 4.50 3.75
2. Ask questions 3.00 4.75 4.75 1.50
3. Demonstrate a skill 3.25 4.50 3.00 2.00
4. Re-read problems 6.50 8.75 5.50 5.75
5. Re-state problems 5.50 8.25 5.25 2.25
6. Supervises activities 8.00 6.25 4.75 5.25
7. Give precautions 6.25 7.50 5.25 4.00
8. Encourage students to give observations 8.50 8.00 5.50 2.00
9. Encourage students to write orderly results 6.75 5.00 3.75 2.50
10. Review results 3.75 5.30 5.50 4.00
11. Encourage to give inferences 5.75 5.25 3.50 3.50

Total 63.25 73.05 51.25 36.50

Analysis of Teachers and Students Activities during Chemistry Lessons

Results of Classroom Observation Schedule

Data were collected from four lessons taken from each of the experimental and control groups. The frequencies of the classroom activities observed in the study were calculated as means and the results reported in Table 9.

Table 9 shows the classroom activities observed during instructions. It attempts to identify possible similarities or differences among teacher/students activities when SPROSMALEA and conventional methods were used in Chemistry lessons.

A perusal of the results indicates that the teacher activities in the experimental groups (E 1 and E 2) outperformed those in the control groups (C 1 and C 2). The total mean scores of teacher activities in the experimental group were 63.25 and 73.05 while in the control group were 51.25 and 36.5. In experimental, teachers manual guided the teacher on what to do. The teacher had to make sure that the objectives were achieved before moving to the next instruction. Learners were required to master the Science Process Skills (experimenting observation and inferences).

Student activities in the experimental groups had a higher mean frequencies than the control groups. This is evident by the total mean score of 85.5 and 83.25 in the experimental groups and 45.26 and 59.25 in the control groups. Use of student manual (Appendix E), must have made learners in the experimental group to be orderly and active, compared to those in the control groups.

Comparing the teacher/student activities, we can see that the students did more activities than the teachers. This is evident by the means of students of 85.5, 83.25, 45.25 and 59.25, teacher activities of 63.25, 73.05, 51.25 and 36.5. This was a learner centre approach, since learners were more involved than the teachers.

Quantitative analysis was supplemented by qualitative description to provide fuller picture of the findings particularly in those areas that are not easily amenable to quantification. The teachers in the experimental groups had to state the objectives to be achieved at the start of the lesson, introduce the topic and also monitor the learners activities during instruction. KIE (2006), recommends that learners centre approach is most appropriate, however learners require teachers guidance. Gavora & Hannafin (1995), from his research said that learning does not occur by only observation but by doing. This implies that interaction should be able to maintain attention and fasten the creation and storage of knowledge and skills.

From the results the students who used SPROSMALEA achieved significantly higher mean scores in the SPSPT than those who did not use. The use of SPROSMALEA offered a departure from the traditional methods of teaching in a classroom and made the learners to be practical oriented. Practical
tests measures the development of the practical skills of the learner in the teaching of chemistry. In this study, the experimental groups out performed the control groups. Experimental groups were able to master the selected process skills (experimenting, observation and inferences) better than the control groups. Allsops & Woolnough (1985); Hudson (1990) in their research showed that practical work in science aids in acquisition of science process skills and scientific knowledge. This approach encouraged practical work, since most of the lessons in this topic salts were mainly class experiments or teacher demonstration. Galyam & Lecrange (2003) did a study in teaching learners some thinking skills and how to improve their use in science. There was improved use of thinking skills, increase of critical discussions and use of meta cognitive abilities as well as acquisition of content knowledge.

Cunningham & Dirk (2006), did a research aimed to teach science process skills that they believed were needed for success in the introductory biology courses. The skills were taught using scanfolding approach that progressively, challenge students to master the skills, while weaving them together through individual homework and small groups work in class. Those who participated learned a topic in depth, think like a scientist and also gain valuable skills. In this study the use of remedial, assignments and feedback helped the learners to master the skills. Feedback helps students identify what they have learned well and what they have not learned well. Areas that were not learned well are allocated more time to achieve mastery. Bizar & Hyde (1989), argued that in many cases learners have to be debriefed identify some of the finer points of what has been observed. The activities are designed however for student investigation not teacher explanation. So debriefing should occur only after experimenting and attempts to make inferences will have been exhausted. Not only must students be actively engaged to learn chemistry but, the teachers must give adequate guidance, support and encouragement while at work when scientific problem is proceeding. The teacher acts as a facilitator creating learning conditions in which students actively engage in experiments, interpret, explain data and negotiate understanding of findings with co-experimenter and peers (National Research Council, 2005).

Teachers in the experimental groups facilitated the practical work done by the students. They moved from one working group to the other, to check whether students were following instructions, making correct observations and recording correct inferences. This enhanced the acquisition of science process skills. Rillero (1998) from his research argued that exhaustive knowledge of science content is impossible, mastery of science process skills enables students to understand a much deeper level, the content they do know and equips them for acquiring content knowledge in the future. Use of SPROSMALEA enhanced the acquisition of science process skills.

**CONCLUSION**

In this article an attempt was made to use the results of the study to test whether the hypothesis was false or true. From the post-test and pre-test results, the mean score, obtained by students in groups E₁ and groups C₁ were not statistically significant. But after treatment, the students who were exposed to SPROSMALEA (E₁) outscored the control group (C₁). Also the mean gain by groups E₁ and (E₂) was higher than that of the control groups (C₁ and C₂).

From the ANOVA results of the post-test, there was statistically significant difference in the means between groups (E₁ and E₂) and adjusted means of the four groups showed that there was statistically significant difference in the means of the four groups. From these results the hypothesis was rejected.

Classroom observation schedule was used to monitor teachers and students activities. From the results the students did more activities than the teachers. This is evident by Table 9. Experimental groups were able to master the selected process skills (experimenting, observation and inferences) than the control groups (Allsops & Woolnough, 1995). Hudson (1990) in their research showed that practical work in science aids in acquisition of science process skills and scientific knowledge. The finding is consistent with several literature sources.

Based on this study, it can be concluded that SPROSMALEA approach enhanced the acquisition of science process skills than the use of conventional teaching methods. This is evident by the significantly high mean scores in the SPSPT attained by experimental groups than those in the control groups.

Chemistry teachers should incorporate this approach in teaching Chemistry at secondary school level especially in the topic salt, where more of the work is experimenting, making observations and inferences. Teachers’ need to make use of more interactive approaches actively involves learners in the teaching-learning process.

**REFERENCES**


