Creative Education
2012. Vol.3, No.8, 1291-1296
Published Online December 2012 in SciRes (http://www.SciRP.org/journal/ce)
http://dx.doi.org/10.4236/ce.2012.38188

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

Roselyn Chebii*, Samwuel Wachanga, Joel Kiboss
Department of Curriculum Instruction and Educational Management, Egerton University, Njoro, Kenya
Email: *kiboss@yahoo.com

Received June 13th, 2012; revised July 20th, 2012; accepted August 2nd, 2012

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 Observaion 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 "sciential" 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.

*Corresponding author.

Ho_1: 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.

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 exists 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 (E_1), Experimental Group Two (E_2), Control Group One (C_1) and Control Group Two (C_2) was used. Groups E_1 and E_2 formed the experimental groups which received treatments (SPROSMALEA) while C_1 and C_2 were the control groups that did not receive the treatment. Groups E_1 and C_1 received pre-test while E_2 and C_2 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 methods of teaching 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.

Groups	Number of students
E_1	38
E_2	39
C_1	46
C_2	37
Total	**160**

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 secondary 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 (E_1), experimental group II, control group I (C_1) and control group II (C_2). A pre-test was conducted in one experimental group (E_1) and one control group (C_1) in order to measure the students entry behaviour before the treatment. In experimental groups E_1 and E_2 SPROSMALEA was used while in control groups C_1 and C_2 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 claas activities observed in the study was calculated as means roups.

Results and Discussion

SPSPT was used to pre-test for the two groups, experimental group (E_1) and control group (C_1). This was done to enable the researcher to check their entry behavior and to determine whether the groups were similar before the commencement of the Chemistry topic on salts.

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 E_1, group (M = 36.41) and C_1 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 (E_1 and E_2) outscored the control groups. E_1 group scored higher mean (M = 58.15) than C_1 group (M = 53.24). Also the mean gain for E_1(21.74) was higher than that of the whole groups (18.08) and for the C_1(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 2.
Independent sample t-test of the pre-test scores on SPSPT.

TEST	GROUP	MEAN	SD	t-value	*P*-value
SPSPT	E_1	36.41	13.22	.95	.34
	C_1	39.11	12.89		.34

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.

Variable	Overall N = 16	E_1 N = 38	C_1 N = 46	E_2 N = 39	C_2 N = 37
Pre-test mean	37.76	36.41	39.11		
S.D	13.06	13.22	12.89		
Post-test Mean	55.84	58.15	53.24	60.58	51.81
S.D	9.99	12.89	10.22	7.54	9.31
Main gain	18.08	21.74	14.13		

Table 4.
ANOVA of the post-test scores on the SPSPT.

Test	Group	SS	DF	Mean square	F	*P*-Value
SPSPT	Between groups	1969.39	3	656.46	6.38	.000
	within groups	15956.36	155	102.94		
Total		17925.75	158			

Note: Mean difference is significant at .05 level.

Table 5 shows the results of post hoc comparisons test of significance for a difference between two means.

The SPSPT means of groups E_1 and C_1, groups E_1 and C_2, groups E_2 and C_1, groups E_2 and C_2 were statistically significant different at .05 α level.

However there was no statistically significant difference in the means between groups E_1 and E_2 groups C_1 and C_2. 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.

Table 5.
Post hoc comparisons of SPSPT post-test means for four groups.

I Group	J Group	Mean differences (I-J)	*P*-value
E_1	E_2	–2.42	.30 (NS)
	C_1	4.92*	.03
	C_2	6.35*	.01
E_2	E_1	2.42	.30 (NS)
	C_1	7.34*	.00
	C_2	8.77*	.00
C_1	E_1	–4.92*	.03
	E_2	–7.34*	.00
	C_2	1.43	.53 (NS)
C_2	E_1	–6.35*	.01
	E_2	–8.77*	.00
	C_1	–1.43	.53 (NS)

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

Table 6.
Adjusted SPSPT post-test mean scores for ANCOVA with KCPE scores as covariate.

Group	N	Mean Score
E_1	38	58.16
E_2	39	60.58
C_1	46	53.18
C_2	37	51.94

Table 7.
Analysis of covariance (ANCOVA) of the post-test score of SPSPT with KCPE.

	Sum of square	DF	Mean squares	F	*P*-value
KCPE	3317.62	1	3317.62	32.07	.00
Group	1900.31	3	633.44	6.12	.00
Error	15933.35	154	103.46		

Note: F = 6.122; DF = 3; $P < .05$. Mean difference is significant at .05 level.

Table 8.
Post hoc pairwise comparisons: Post-test score of SPSPT.

I Group	J Group	Mean differences (I-J)	*P*-value
E_1	E_2	–2.36	.32 (NS)
	C_1	4.98*	.03
	C_2	6.22*	.01
E_2	E_1	2.36	.32 (NS)
	C_1	7.33*	.00
	C_2	8.57*	.00
C_1	E_1	–4.98*	.03
	E_2	–7.33*	.00
	C_2	1.24	.59 (NS)
C_2	E_1	–6.22*	.01
	E_2	–8.57*	.00
	C_1	–1.24	.59 (NS)

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

1) Groups E_1 and C_1
2) Groups E_2 and C_1
3) Groups E_2 and C_2
4) Groups E_1 and C_2

The differences in means of the groups E_1 and E_2 and groups C_1 and C_2 were not statistically significant. It is evident the SPROSMALEA had similar effects to both experimental groups. But the control groups C_1 and C_2 denied of this treatment had a lower mean score and hence were outperformed by the experimental groups. The results of ANOVA and ANCOVA confirm that there was a statistically significant difference in the mean scores of the experimental and control groups. Therefore HO_2 was rejected.

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 method 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

Table 9.
Comparisons of teachers and students activities during chemistry lessons on salts.

Teachers activity	Means of frequencies groups			
	E_1	E_2	C_1	C_2
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**
Student activity	**Means of frequencies groups**			
	E_1	**E_2**	**C_1**	**C_2**
1. Respond to teachers question	5.50	5.25	2.75	3.25
2. Follow instructions	5.75	5.70	1.25	4.00
3. Perform experiment	8.25	7.50	3.25	4.75
4. Makes observations	5.00	5.75	4.50	4.50
5. Recalls properties	6.50	2.75	3.25	2.00
6. Identify changes occurring in a reaction	6.75	6.00	3.25	5.50
7. Identify observable characteristics	5.75	5.00	2.50	3.50
8. Infer relationship	5.00	7.50	2.00	3.75
9. Infer an effect	5.00	3.75	1.75	3.50
10. Ask questions	3.75	3.25	1.50	2.50
11. Consult other students	6.75	5.75	4.25	3.25
12. Express agreement or disagreement with action	3.75	6.50	3.50	5.00
13. Repeat experiments to clarify the results	2.25	2.00	1.75	2.50
14. Take precautions	5.75	8.75	2.50	2.75
15. Contribute during class discussion	4.75	5.00	4.50	5.00
16. Give conclusions	2.75	3.75	2.75	1.25
Total	**85.5**	**83.25**	**45.25**	**59.25**

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 amendable to quatification. 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 scanffolding 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-experimenters 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

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 E_1 and groups C_1 were not statistically significant. But after treatment, the students who were exposed to SPROSMALEA (E_1) outscored the control group (C_1). Also the mean gain by groups E_1 and (E_2) was higher than that of the control groups (C_1 and C_2).

From the ANOVA results of the post-test, there was statisticcally significant difference in the means between groups (E_1 and E_2) 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

Ajaja, O. P. (2007). *Teaching methods across disciplines.* Agbor: Allwell Publishers.

Allsops, T., & Woolnough, B. (1985). *Practical work in science.* Cambridge: Cambridge University Press.

Bizar, M., & Hyde, A. A. (1989). *Thinking in context: Teaching cognitive processes across the elementary school curriculum.* White Plains, NY: Longman.

Borg, W. R., & Gall, M. D. (1989). *Educational research. An introduction* (5th ed.). White Plains, NY: Longman.

Das, R. S. (1985). *Science teaching in school.* New Delhi: Sterling Publishers.

Dirks, C., & Cunningham, M. (2006). Enhancing diversity in science: Is teaching science Process skills the answer? *Life Science Education, 5,* 218-226.

Fraenkel, R. J., & Wallen, E. N. (2000). *How to design and evaluate research in education* (4th ed.). San Francisco: McGraw-Hill.

Galyam & Lecrange (2003). Teaching thinking skills in science to learners with special needs. *International Journal of Special Education, 18,* 84-94.

Gavora, M. J., & Hannafin, M. J. (1995). Perspectives on the design on human-computer interactions. Issues and implications. *Instructional Science, 22,* 445-447.

Hodson, D. (1990). A critical look at practical work in school science. *School Science Review, 71,* 33-40.

Kenya Institute of Education (2002). *Teacher's preparation guide*. *The New Secondary Education Curriculum*. Nairobi: Self.

Kenya Institute of Education (2006). *Secondary chemistry teachers handbook.* Nairobi: Self.

Mugenda, O., & Mugenda, A. (2003). *Research methods quantitative and qualitative approaches*. Nairobi: Act Press.

Mutai, K. B. (2000). *How to write quality research proposals*. New Delhi: Thellery Publications.

National Research Council (2005). *How students learn science in the classroom*. Washington DC: The National Academy Press.

Ohodo, G. C. (2005). Principles and practice of chemistry education in Nigeria. Enugu: Enugu State University of Science and Technology.

Rillero, P. (1998). Process skills and content knowledge. *Science Activities, 35*, 3.
Ross, B. (2000). *Modern trends in education*. London: The Macmillan Press Ltd.
Wachanga, S. W. (2002). *Effects of cooperative class experiment teaching method on secondary school student's motivation and achievement in chemistry*. Ph.D. Thesis, Njoro: Egerton University Njoro.
Wheeler, G. F. (2000). Three faces of inquiry. In J. M. Instress, & E. H. Van Zee (Eds.), *Inquiring into inquiry learning and teaching in science* (pp. 14-19). Washington DC: American Association for the Advancement of Science.