Effectiveness of Self-study Material for Teaching General Science to School Students

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Abstract

In this quasi-experimental study, the traditional method adopted for teaching general science to Class IX students was compared with teaching through self-study material (SSM) for teaching general science to same students. The basic purpose of the study was to study the effectiveness of the developed SSM in comparison to the traditional teaching method for teaching general science to Class IX students. In order to accomplish these, two groups were formed, namely experimental and control. Experimental group was taught through the SSM developed by the investigator and control group was taught through the traditional method on the same curricula. Both the groups were pretested and post-tested on the three criterion variables such as criterion test, scientific reasoning, and scientific attitude. The decision regarding the comparative effectiveness of the two methods of teaching science was arrived at by comparing gain scores on the three criterion variables.

Need for the Study

One important front for improving the quality of teaching in any subject is the provision of an effective teaching-learning material. There are many methods, models and techniques which can be used to make an instructional process effective. SSM is one of them. Use of SSM makes the teachers' job easy and can solve some of the problems of present classrooms. It has the potential to improve the quality of teaching. Research studies conducted in India and abroad reveal that SSM is significantly better than traditional face to face teaching. The most obvious justification for self instruction is that there are circumstances where there is no alternative or where any alternative involves the learner in unacceptable

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personal sacrifice. Thus the learner may live at a considerable distance from an appropriate institution, the learners' job may not allow him the free time or the time at the right part of the week to attend classes or the learner may be disabled and unable to attend classes. The learner's learning need may not fit with the available courses in various ways, the learner may require a particular competence in a relatively short time, the learner may need to learn bits of the subject which are underemphasized or not touched upon by most courses. This calls for a flexible approach to learning in the form of SSM.

The second reason for advocating SSM is that it is a way of coping up with various sort of differences among learners. Some learners learn more quickly than others. They differ in their performances in learning, e.g. some cannot remember anything unless they write it down, and others have very good oral memories and so on. All learners manifest certain preferred learning strategies and learning is likely to be most effective if the learner is prevented from learning in the ways he prefers.

Importance of these differences has long been recognised in learning and is the main justification for the thrust towards individualised learning.

Self-learning encourages learners to take on greater responsibility for their own learning. Thus learners are encouraged to consider their own learning needs and in some cases to undertake substantial analysis of them. In this way, the learners become aware of possible goals, stages, and sequences in learning the subjects. They are encouraged to select relevant goals and subgoals at wish to aim, monitor, and assess their achievements through various self-assessment techniques. SSM seeks to give to the learner as much responsibility for his learning as he can cope up without any particular time. Here the learner retains responsibility for the aim and objective of the course. He monitors the development of the course and its continuing relevance to his own objectives. The learner is aware of how well he achieves the learning task and has a reasonable idea of his level of proficiency. The learner has the opportunity to negotiate the course and so he becomes a participant in decision-making rather than a passive object to which things are done.

Further, affective factors merit a special importance in learning. A self-instructional mode can help to control affective factors. For instance, empathy may be developed within a group of learners by reducing the centrality of the teacher so that his role becomes more than a consultant. This is likely to increase the empathy between the teacher and learners. Rogers (1969) argues that where the teacher is empathetic, liking and affection are more evenly diffused around the group; and every student tends to feel liked by all the others to have a more positive attitude towards him and towards school. Individualisation reduces competition by making a better attempt than lockstep modes to match objectives and materials to individual learners' need and level. Autonomy grows through, inter alias,

individuals being given practice in taking decisions and so accepting responsibility for their own learning, through cooperating with others in groups to work on problems and to produce a mutual solution, through exchanging ideas and opinions with others; and through discovering about authority figures and autonomous individuals through reading, then there are great opportunities for the development of autonomy in teaching/ learning. SSM provides autonomy and freedom to carry on self-directed learning.

There are economic, social and individual pressures on the educational system to provide continuing education. The rate of change in modern society through technological developments, economic and commercial development and political groupings, may strain the ability of educational system to cope. With the increase of knowledge and associated developments in technology, there are changes in equipments and process which require a parallel development in specialists' skills together with new patterns of work involving higher degree of collaboration among specialists. The strain on the agencies presently providing continuing education can be reduced by the adoption of some form of self-instructional mode. In addition, the clients of continuing education frequently are those who are unable to fit into the normal schedules of educational institutions and so a self-instructional mode may help to provide the learning opportunities required.

Research says that there is a relationship between self-learning and motivation. Self learning is concerned with helping learners to develop their own motivation. Within a self instructional teaching mode there is a higher degree of likelihood that the learner will be aware of his needs and goals. This may be because he has special needs for the subject or it may be because the teacher has discussed needs and goals with the learners as part of the process of facilitating self instruction. The learners' involvement in decision-making has a positive effect on motivation. First, there is evidence (Brown, 1964) that involvement in decision-making tends to result in increase productivity through increase motivation to perform effectively. Second, such involvement may have the effect of building or at least maintaining the learners' self-esteem. The degree of freedom has to use preferred learning technique also likely to have an effect on motivation. Research conducted elsewhere reveals that any technique sincerely adopted by a learner as a way of coping is more likely to help than not on the ground that the personal assumption by the learners of responsibility for his own learning is a fundamental prerequisite for success in learning. By contrast, if the learner is prevented from using his favoured techniques, this is likely to reduce his learning effectiveness and so be demotivating.

In the light of the above considerations, it is hypothesised that SSM will prove to be more academically viable than traditional face to face teaching-learning approach. This hypothesis is theoretically substantiated by the fact that SSM

designed as self-contained course will prove to be academically viable for students because it would provide them opportunities to learn according to their own pace, encourage learners to take on greater responsibility for their own learning by experiencing the study work on their own which is felt to develop independence and lead to greater autonomy than traditional teaching method. It will prove to be more economically viable because SSM can be used as a distance-learning material and would offer the following economic advantages which distance education offers in general:

i. The applicability of distance to large group of learners as a kind of mass communication.

ii. The economy of both the large group approach and of the fact that the need for residential teaching is eliminated and diminished and that the study can take place during any time and anywhere when students feel the need;

iii. The feasibility for large scale projects to enlist the services of the very best subject teachers and educationists. For example they can be utilised to write the course materials.

Besides, there are empirical and psychological considerations that show that learning and retention is enhanced through the study of written materials produced on the basis of certain psycho-educational theories. For instance, influential works of Ausubel (1968) on meaningful verbal learning and the notion of Mathemagenic behaviour introduced by Roth Kopf (1965). Although Ausubel's work drew attention to meaningful text learning, it was Roth Kopf, according to Faw and Waller (1974), who showed how investigations should be carried out in this field. He suggested that subjects, when studying written materials not only learn this specific content but also acquire some general facilitative skills namely inspection behaviours which he later called Mathemagenic Behavoiurs. This reminds researchers that what the student does in the learning situation is an important key to how much he will retain. Based on these conditions, the investigator in the present study has attempted to determine whether the deliberate use of self-instructional material developed by utilizing the above psychological foundations could influence learning positively amongst school students. Further the setting chosen for the study was not a laboratory but a real teaching situation.

It is therefore expected that the SSM which makes use of auto-instructional strategy would result in positive transfer to new situation and deeper cognitive processing and hence better learning than traditional face-to-face teaching. Further better learning and positive transfer of this learning to new similar situations is expected to result in significant gain in scientific reasoning and scientific attitudes among students. To support this, research studies conducted in India and abroad by Desai (1966), Taveggia (1976), Mc Carney and Bullock (1977), Johnston and Pennypacher (1977), Otto (1981), Edelman (1983), Grant

(1983), Mathur (1983), Shah (1984), Rabindradas (1984), Neuberger (1984), Vatanvigkit (1985), Desai (1986), Singh (1988), Aranha (1988), Das (1990), Siddiqi (1991), and Agarwal (1995), reveal that SSM is significantly better than traditional face-to-face teaching in terms of academic achievements and reaction of the learners towards it. Similarly, the economic viability of SSM over traditional face-to-face teaching and traditional textbook reading has been established beyond doubt (Holmberg, 1973).

Statement of the Problem

In the light of the above background and justification, the title of the study was stated as "Effectiveness of Self-study Material for Teaching General Science to Class IX students of Assam State" with a view to realising the following objectives:

Objectives of the Study

The study aimed at achieving the following objectives:

1. To study the effectiveness of self-study material in terms of criterion test and reaction towards it.
2. To compare the mean performance scores of students taught through the developed SSM with those taught through the traditional method taking intelligence as a covariate.
3. To compare the mean scientific reasoning scores of students taught through the developed SSM with those taught through the traditional method taking intelligence as a covariate.
4. To compare the scientific attitude scores of students taught through the developed SSM with those taught through the traditional method taking intelligence as a covariate.
5. To compare the reactions of male and female students towards the developed SSM.
6. To study the reactions of students towards the developed SSM.

Hypotheses

The following hypotheses stated in null form were subjected to empirical verification;

Ho1. There will be no significant difference between the mean performance scores of the students taught through the developed SSM with those taught through the traditional method when intelligence will be taken as a covariate.

Ho2. There will be no significant difference between mean scientific reasoning scores of students taught through developed SSM with those taught through traditional method when intelligence will be taken as a covariate.

Ho3. There will be no significant difference between scientific attitude scores of students taught through developed SSM with those taught through traditional method when intelligence will be taken as a covariate.

Ho4. There will be no significant difference between the reactions

of male and female students towards the developed SSM.

Sample

Present study has been conducted at two stages. In stage one, the empirical validity of the developed SSM was established through small group tryout. For this, ten students were selected. In stage two for the final study another group of 58 students was selected. In this way two samples were used for the study. Details of both the samples are given hereunder.

Sample for Small Group Tryout

Purposive sampling technique was employed to select the sample for small group tryout. The sample comprised of ten students of Class IX of the session 2010. Out of the 10 students five were male and five female. The age of the students ranged from 13 to 15 years.

Sample for Final Study

Keeping in view the feasibility to conduct the experiment, all the 58 students of Class IX were selected for the study. Thus the intact group, i.e. the pre-existing group was selected purposively for the experimental and control purposes. The sample size in the experimental and control group was comprised of equal number of 29 students in each group. However, experimental treatment was assigned to the experimental group by random procedure. Age of the students ranged from 13 to 15 years.

Design

In this study, random assignment of subjects to the experimental and control groups was not possible because there were administrative difficulties in distributing the students without interfering normal classroom setting of the school. Further, it was also not permitted by the Head master of the school selected in the study. Hence the quasi- experimental design Number 10 suggested by Campbell and Stanley (1966) was found to be suitable and employed to study the effectiveness of the developed SSM as compared to the traditional method. There were only two groups: experimental and control. The subjects of the study were 58 Class IX students. They were divided into two equal groups. The students of experimental group were treated with developed SSM. The investigator was a guide to the students and was available throughout the experiment. The group which received instruction through traditional method was named as control group. Four units selected from general science as prescribed by SEBA were taught to both the experimental and control groups. Both the groups received instruction thrice a week in regular periods. Some periods were taken to hold discussions and perform other activities like assignments and library references. However, treatments to the experimental group were assigned by following random procedure.

Studies conducted in India and abroad report that there is a positive relationship between intelligence and students achievements. Hence in order to control intelligence statistically it was taken as a covariate in this study. The dependent variables in the study were achievement, reaction of the students, reasoning ability in science and scientific attitude. The independent

variables were treatments on SSM, traditional method and gender.

Tools

The following tools were used for data collection in the study:

1. Intelligence Test: Developed by Asthana and Verma (1989). The reliability and validity of the test was found to be 0.82 and 0.74, respectively.
2. Scientific Reasoning Test: Developed by Mohapatra (1993). The reliability and validity of the test was found to be 0.76 and 0.40, respectively.
3. Scientific Attitude Scale: Developed by Srivastava (1997).
4. Criterion Test: Four criterion tests on four units of general science were developed and used in the study by the investigator
5. A Reaction Scale: Developed by the investigator was used in the study.

Procedure of Data Collection

The procedure of data collection from both experimental and control groups is described below.

i. Data Collection from the Experimental Group

As stated above, 29 students of class IX received treatments on the SSM and formed the experimental group. Before conducting the experiment, the group was pre-tested for their performance in general science on selected four units, scientific reasoning ability and scientific attitude by administering criterion tests, scientific reasoning test, and scientific attitude scale. After that proper instruction and orientations were given to the students of this group. Then the group was treated with the developed SSM on the selected four units, namely, accurate measurement, motion, work, power and energy; and heat in general science for at least 40 minutes per day and thrice in a week. After the end of the period, SSM was collected from the students. The treatment on these four units was completed in six, fourteen, eight and six periods of 40 minutes, respectively. The entire process of treatment was completed in thirty four periods. After receiving treatment on the SSM, four to five minutes were provided for interaction with the teacher. Library references were given to the students to help them in doing the assignments. After completing a unit, criterion test was administered. In the same way, remaining three units were completed. Side by side, intelligence test was administered. After the completion of the treatment on all the four units, scientific reasoning test, scientific attitude scale, and reaction scale were administered.

ii. Data Collection from the Control Group

Twenty nine students were selected in the control group. The students of control group were also pre-tested for their performance in general science on selected four units, reasoning ability in science and scientific attitude by administering the same criterion tests, scientific reasoning test, and scientific attitude scale, respectively, as done in the experimental group. After giving proper orientation they

were also taught the same syllabus as taught to the experimental group. This group did not receive any special treatment. Each of the unit was taught by the investigator through the traditional chalk and talk method. After accomplishment of each unit same criterion test was administered to the students of control group. In this way all the four criterion tests were administered. Side by side intelligence test was administered. After the completion of giving treatment on all the four units, scientific reasoning test, and scientific attitude scale were administered.

Statistical Techniques Used

t-test, percentiles, percentage, chi-square values, and analysis of covariance were used for analysis of data.

Self-study Material

Selection of units was the first step for developing SSM. In this study, units were selected from general science syllabus of Class IX, prescribed by Board of Secondary Education, Assam. Selected units were: i Accurate Measurement, ii. Motion, iii. Work, Power, and Energy, and iv. Heat.

Before developing the SSM the investigator consulted with the formats adopted by selected institutions in India, viz. IGNOU, DAV Institutes of Distance Education and the NCERT. It was found that there are three basic parts in the entire format: introduction to the unit which appears before presentation of the content, main body of the content, and the concluding part which appears after the presentation of the main body of the content. Further, from the review of literature with respect to various steps followed for developing SSM by different organisations and scholars, it is seen that the steps namely, i. content analysis, ii. specification of objectives, iii. development test items, iv. development of draft lessons, / units, v. tryout and modification are almost common. Steps like description of target group, entry behaviour, and selection of media are not found to be common. Taking into consideration the above five common steps along with the variations, seven steps were followed by the investigator for developing the SSM. The steps followed were:

i. Description of the target group;
ii. content analysis;
iii. specification of objectives;
iv. development of test items;
v. identification of entry behaviour;
vi. development of draft lessons/ units; and
vii. tryout and modification.

Analysis and Interpretation

This section attempts to study the effectiveness of SSM in terms of criterion test and reactions of the students.

The effectiveness of the SSM in terms of performance of students on criterion test was studied on four units of general science taught to the students of Class IX. To obtain the performance of students, four criterion tests developed by the investigator on selected units were administered to the students of experimental group before instruction (pretest) and after

instruction (post–test). After that average scores of each student on pretest and post-test was found out. Effectiveness of the SSM was studied by comparing mean pre-test performance with mean post-test performance. Further, effectiveness of the SSM was studied in terms of performance of students on different criterion tests and performance as a whole. To compare the pretest performance and post-test performance of students,'t' value was calculated. Table 1 shows the't' value and the result of analysis done.

The results of analysis in Table-1 indicate that't' value of performance is 4.87 which is significant at .01 level of significance. This means that significant gains occur in students' performance on criterion test. Further, in order to verify the effectiveness of the SSM in terms of performance on criterion test, post-test scores of the students were analysed by computing percentiles. The results are given below in Table 2

The results presented in Table 2 indicate that more than 70 per cent students secured above 30 per cent

Table-1: Pretest and Post-test Comparison of Performance of Students on Criterion Test

Variable	*Pretest*		*Post-test*		*rxy*	*'t' value*
	Mean (Mx)	S.D	Mean (My)	SD		
Criterion Test	40.69	5.06	27.62	29.91	0.91	4.87

Table 2: Scores Obtained by Students on Different Criterion Tests

Criterion Tests					
Percentiles	*Unit I*	*Unit II*	*Unit III*	*Unit IV*	*Mean Performance*
P90	79.83	78.00	85.70	86.33	83.17
P80	70.17	73.17	79.90	81.50	75.90
P70	65.00	68.10	72.75	73.83	70.10
P60	60.17	62.30	61.50	64.17	63.00
P50	47.80	52.00	53.25	54.50	54.50
P40	38.50	48.17	46.00	46.00	46.00
P30	31.25	38.50	38.50	43.75	38.50
P20	25.10	28.80	29.17	36.50	29.17
P10	19.17	19.17	24.33	25.30	24.33

marks, 60 per cent students secured above 45 per cent marks except criterion test 1, 40 per cent students secured more than 60 per cent marks on all the criterion tests, and more than 10 per cent students secured above 80 per cent marks on different criterion tests. Hence the results indicate satisfactory students' performance on criterion tests. It means that the developed SSM was found to be effective in terms of performance of the

students on criterion tests. Students' reactions towards the SSM were obtained by administering a reaction scale developed by the investigator. The obtained data were analysed by using percentage and chi-square test. The reaction scale consisted of fifty items covering five aspects of the SSM. There were ten items in each aspect and five options against each item. Students were asked to put a tick mark on one of the options.

First aspect of the reaction scale elicited reactions from the students with respect to their liking/ disliking towards the developed SSM. It was found that 82.76 per cent of students reacted that subject matter presented through the SSM is very easy to follow. 10.34 per cent students were not in a position to react towards this item. Only 6.90 per cent students were not agreed on this item. 75.87 per cent students were of the opinion that the SSM helps to understand the content without much external support, 6.90 per cent students were unable to decide their responses on this item, whereas 17.24 per cent students were not agreed on this item. 72.41 and 93.10 per cent students agreed that the atmosphere of learning through SSM is healthy in terms of distracting stimuli and it is very interesting to learn through the SSM, respectively. Only 10.35 per cent students disagreed with the former and no one disagreed with the later. However, 17.24 and 6.90 per cent students could not say anything about these two items.

89.66 per cent students were of the opinion that the SSM could not be used to facilitate learning, 6.90 per cent students were not in a position to react towards this item and only 3.45 per cent students disagreed with this. 82.76 per cent students reacted that they remain motivated through the learning process, 6.90 per cent students could not say anything whether they were motivated or not, whereas 10.35 per cent students showed their disagreement on this item. 79.31 per cent students wanted to learn other subjects with the help of the SSM, 13.79 per cent students were not able to react towards this item and only 6.90 per cent students were not agreed with this item.

There were three negative items in the reaction scale, such as sometimes it is boring to learn through the SSM, there is wastage of time in learning through the SSM, and it is very difficult to interact with the SSM. 62.07 to 72.14 per cent students disagreed with these items, 10.34to 17.24 per cent students did not react to these items, and 17.24 to 20.68 per cent students showed their disagreement on them. On the other hand, all the chi-square values were significant except the item: sometimes it is boring to learn through the SSM. It means that the deviation of observed reactions from expectation might be a matter of chance. Results in terms of percentage indicate that students reacted favourably towards the SSM with regard to instruction through the SSM.

Second aspect of the reaction scale was about the presentation of the content. There were eight positive items in this aspect, such as the subject matter presented in small steps is easy to understand, help of the teacher

is sufficient to learn, the linkage of different concepts are well done, the content presented in conversational style is friendly to learn, provision of different examples and explanations for a concept help to learn effectively, there are sufficient illustrations to explain the content, explanation of technical words helps in learning, and integration of different illustrations and examples with the content was quite good. 89.66, 96.55, 75.86, 89.65, 86.20, 65.52, 72.41, and 75.86 per cent students respectively reacted favourably towards these items. 3.45 to 31.03 per cent students were not able to react towards these items and only 3.45 to 17.24 per cent students disagreed with these items. There were two negative items such as there should be compulsion to learn in same sequence and explanation of technical words not necessary. 65.52 and 62.07 per cent students respectively disagreed with these items. 10.34 per cent students were not in a position to react to the former and 31.03 per cent were not in a position to react to the latter. Only 30.13 per cent students agreed with the former and 6.90 per cent on the later. The chi-square values with respect to presentation of content were significant. This reflects that the students liked the presentation of the content.

Third aspect of reaction scale was about the technical facilities available. 13.79 per cent students were not in position to react towards this, whereas 13.80 per cent students disagreed with this. 79. 31 per cent students were of the opinion that highlight of the main and important points helped them to learn the concept. 10.34 per cent students did not react towards this item, whereas 10.35 per cent students were not agreed with this. 62.06 per cent students reacted that presentation of the content was quite motivating, 17.24 per cent students were not able to give response towards this item and only 26.69 per cent students disagreed with this. 93.10 per cent to 72.41 per cent students were of the opinion that graphics help to understand the concepts, adequate selection of learning material save time in learning, in-built mechanism for shifting one step to another helps in learning, 3.45 per cent to 13.79 per cent students could not be able to determine responses towards these items, whereas 3.45 to 13.79 per cent students were disagreed with these items. There were three negative items in this aspect, such as instructional facilities are not sufficient in each step, animation and graphics have no use in learning, and in-built flexibility of the SSM hinders learning. 58.62 to 86.21 per cent students disagreed with these items. Only 24.13 per cent to 13.79 per cent students agreed with the same. All the chi-square values were significant in this aspect and hence the students favoured the technical facilities available in the SSM.

Fourth aspect of the reaction scale was about evaluation and feedback. 82.76 per cent students reacted favourably towards the item, i.e. sufficient explanations are given for the answer of the questions. 6.90 per cent students were not in a position to react towards this item, whereas 10.35 per cent of them disagreed with the same.

89.66 per cent students reacted that questions are relevant to the content, whereas 6.90 per cent students did not find them relevant and 3.45 per cent students were not able to react to this item. 65.52 per cent to 86.21 per cent students were of the opinion that questions are quite helpful in developing higher mental abilities, there is a sufficient scope to evaluate the learning outcomes, only multiple choice items are not sufficient to develop understanding and expression, explanation of wrong answers helps to learn more clearly, sometimes prompts are useful to draw the information, immediate confirmation of the answers helps to understand the concept, I like this in-built evaluation facilities and suggestions given after committing mistakes and correct answer helps to learn more clearly. 3.45 per cent to 20.69 per cent students were not able to react towards these items, whereas 3.45 to 20.69 per cent students were not agreed with these items. All the chi-square values are found to be significant. This reflects that the group really favoured the evaluation and feedback facilities of the SSM. The fifth aspect of reaction scale was about follow-up activities. In respect to this, it was found that 93.11 per cent students reacted favourably towards the item: integration of activities with the SSM helps the students very much. 6.90 per cent students could not find their responses and no one disagreed with this item. 75.86 per cent to 89.65 per cent students reacted favourably towards the items , such as assignments create the opportunity for discussion, discussion on main points helps the students to consolidate learning, hints should be incorporated with assignments, and reacting with others are necessary for clarifying doubts. 6.90 per cent students were not able to react towards the later three items and only 3.45 per cent to 17.24 per cent students disagreed with these items. 82.76 per cent students reacted that reasoning based assignments are feedback for the students. 6.90 per cent students could not find their responses towards this item, whereas 10.35 per cent students were not agreed with this item. 72.42 and 75.86 per cent students reacted favourably towards the items, such as clarifying doubts through discussion is helpful for the students' and knowing each other through discussion is new experience for me, respectively. 10.34 per cent to 20.69 per cent students could not find their responses towards these items, whereas 17.24 per cent students disagreed with the former and 3.45 per cent students disagreed with the later. There were two negative items in this aspect, such as assignments do not help us to test the knowledge gained and sometimes assignments are not found in given reference books. 68.97 and 51.73 per cent students were not agreed with these two items. 17.24 and 31.03 per cent students were not able to give their responses towards these two items, whereas 13.79 per cent students were agreed with the former and 17.24 agreed with the later. All the chi-square values were found to be significant with respect to follow-up activities. This reflects that students liked the follow-up activities provided by the investigator right after

the treatment on SSM. On the whole, majority of students reacted favourably towards the reaction scale. Hence, it can be concluded that the developed SSM was found to be effective in terms of students' reaction towards it.

Comparison of the SSM with Traditional Method in terms of Performance of Students

In this study, as mentioned above, four criterion tests were administered to both experimental and control groups before and after instruction to get pretest and posttest scores. After this, performance scores of each student was found out by subtracting the pretest score from post-test score in each of the criterion test. Thereafter, mean performance scores of the students on four criterion tests, both experimental and control groups were found out. The obtained data were analysed by using Analysis of Covariance (ANCOVA) taking intelligence as a covariate. The results are presented in Table 3 and 4. From the Table 3, it can be seen that F value of mean performance for two groups is 37.94 which is significant at .01 levels with df 1/55. It shows that the adjusted mean performance score of the students taught through the developed SSM is significantly different from those taught through traditional method when intelligence is taken as a covariate.

Table 3: Summary of ANCOVA for Mean Performance by Taking Intelligence as a Covariate

Sources of Variance	*df*	*SSy.x*	*MSSy.x*	*Fy.x*
Among Means	1	641.92	641.92	
Within Groups	55	930.83	16.92	37.94
Total	56			

Table 4: Adjusted Mean Performance Scores of Experimental and Control Groups

Group	*N*	*Mx*	*My*	*My.x*
Experimental	1	641.92	641.92	
Control	29	22.14	17.38	16.82

From Table 4, it is seen that the adjusted mean performance of the students taught through the developed SSM was significantly higher than the students taught through traditional method. Thus, the null hypothesis 'there will be no significant difference between the mean performance scores of the students taught through the developed SSM and those taught through the traditional method when intelligence will be taken as a covariate' is rejected. It is therefore concluded that the developed SSM is significantly better than the traditional method.

Comparison of the SSM with Traditional Method in Terms of Scientific Reasoning

The scores of scientific reasoning were obtained by administering Reasoning Ability Test in Science (RATS) to the students of both the groups, such as experimental and control. Thereafter, the gain scores of both the groups were found out by subtracting the pretest scores from the post-test scores. Then the mean gain scores of the students taught through the SSM was compared with mean gain scores

of students taught through traditional method. The data were analysed by using ANCOVA taking intelligence as a covariate. The results are presented in Table 5 and 6.

Table 5: Summary of ANCOVA for Scientific Reasoning Taking Intelligence as a Covariate

Sources of Variance	*df*	*SSy.x*	*MSSy.x*	*Fy.x*
Among Means	1	141.34	141.34	
Within Groups	55	139.35	2.53	55.87
Total	56			

From Table 5 it can be seen that the F value of scientific reasoning ability for the two groups is 55.87 which is significant at .01 levels with df 1/55.

Table 6: Adjusted Mean Performance Scores of Experimental and Control Group

Group	*N*	*Mx*	*My*	*My.x*
Experimental	29	20.62	5.38	5.41
Control	29	22.14	2.31	2.28

Table 6 shows that the adjusted mean scientific reasoning score of the students taught through the developed SSM is significantly different from those taught through the traditional method taking intelligence as a covariate. Thus the null hypothesis 'there will be no significant difference between the mean scientific reasoning scores of students taught through the developed SSM with those students taught through the traditional method when intelligence will be taken as a covariate' is rejected. The scientific reasoning score of the students taught through the developed SSM was significantly higher than those taught through the traditional method. It is therefore concluded that the developed SSM induced more scientific reasoning ability among the students than the tradional method of teaching.

Comparison of SSM with Traditional Method in Terms of Scientific Attitude

The scores on scientific attitude were obtained by administering the scientific attitude scale developed by Srivastava (1997). The test was administered on both the groups: experimental and control. After that the gain scores of the students taught through both the approaches were found out by subtracting the pretest scores from the post-test scores on scientific attitude. Thereafter, the mean gain scores of the students taught through the SSM were compared with mean gain scores of students taught through the traditional method. This comparison was done by using ANCOVA. The details are presented in Table 7 and 8.

From Table 7, it can be seen that the F value of scientific attitude for the two groups is 0.21 which is not significant at .01 levels with df 1/55.

Table 7: Summary of ANCOVA for Scientific Attitude Taking Intelligence as a Covariate

Sources of Variance	*df*	*SSy.x*	*MSSy.x*	*Fy.x*
Among Means	1	0.30	0.30	
Within Groups	55	80.36	1.46	55.87
Total	56			

Table 8 : Adjusted Mean Scientific Attitude Scores of Experimental and Control Groups

Group	N	Mx	My	My.x
Experimental	29	20.62	1.93	1.95
Control	29	22.14	2.10	2.08

Table 8 shows that the adjusted scientific attitude score of the students taught through the developed SSM is not significantly different from those taught through the traditional method when intelligence is taken as a covariate. Thus the null hypothesis 'there will be no significant difference between the scientific attitude scores of the students taught through the developed SSM with those taught through the traditional method when intelligence will be taken as a covariate' is not rejected. This means that the alternative research hypothesis is accepted and it is concluded that the SSM does not have any significant influence on the scientific attitude of the students.

Findings

Based on the interpretation of results, the following are the findings of the study:

1. Developed SSM was found to be effective in terms of performance of the students on criterion tests and reaction towards it. More than 70 per cent of students secured more than 30 per cent marks and reaction of the students towards different aspects of the SSM and material as whole was found to be favourable.
2. The performance of students taught through the developed SSM was found to be significantly better than those taught through the traditional method when students overall performance scores were adjusted with respect to intelligence.
3. The developed SSM was found significantly better than the traditional method in terms of development of reasoning ability of students in science when their mean scores were adjusted with respect to intelligence
4. The developed SSM was not found to have any significant positive effect on scientific attitude scores of the students when compared with the traditional method taking intelligence as a covariate.
5. There was no significant difference in the reactions of male and female students towards the developed SSM, as the chi-square values are not found significant in all the items given in the reaction scale. Thus the null hypothesis 'there will be no significant difference between the reactions of male and female students towards the developed SSM' is not rejected. Hence the alternative research hypothesis is accepted and it is concluded that the SSM does not have any significant influence on the reaction of the male and female students.

Conclusion

Teaching through SSM is significantly better than the traditional talk and chalk method for teaching General Science to Class IX students. Moreover,

the SSM has induced better scientific reasoning abilities among the students than the traditional method. But there is no significant difference between the students taught through the SSM and those taught through the traditional method in terms of scientific attitude. Students' reaction towards the developed SSM for teaching General Science has been found to be positive. Hence, the SSM could be effectively used as a viable teaching strategy for teaching General Science to the students of Class IX.

Implications of the Study

The developed SSM was used for teaching General Science and was found to be effective than the traditional method of teaching. It has brought about significant changes in the scientific reasoning abilities of the students. This implies that the science teachers can take the help of such material and procedures involved in it and make their classroom teaching effective. By following the principles of developing the material, science teachers can develop SSM for teaching. By collecting available materials not only for teaching science but also for teaching other subjects and using such material as a support system, the teacher can improve his teaching efficiency and fulfill the present requirements of classroom teaching.

To cope up with the present changing society, the teacher should have sufficient knowledge in each and every field which is impossible in the present classroom setting having wide variety of students, and a single teacher following a single teaching method. The material developed and used in the present study has proved to be effective for students in learning in terms of learning on their own. Therefore, SSM could be used for effective self-learning by the students. Besides, it could be used to develop awareness among the students about the use of SSM in learning situations and provide training in the use of such material.

In order to use the SSM to its maximum level, it is essential to train more teachers in its development and use. Training of teachers in SSM could be done by the teacher training institutes for both pre-service as well as in-service programmes. They should try to introduce a paper at their teacher training programmes to create trained manpower in the area of SSM. The teacher educators can also start conducting researches in the area of self- instruction. The present study is a guideline for them.

The study opens up a new path for the administrators, principals/ headmasters, directors, educational officers in the sense that they should cultivate positive attitude towards the development and use of SSM from economic point of view. They should try to modify the curriculum and encourage both teachers and students for the use of the SSM.

The development of SSM for the instructional processes requires two things, viz. mastery over the subject matter and adequate knowledge of developing SSM. Generally, the subject experts have the mastery over the

subject but they may not have sufficient knowledge about how to analyse the content following psychological principles, what principles and steps to be followed in developing SSM and how to use different strategies in the package for achieving the educational goals. The developed material in the study is a guideline to those who are engaged in developing SSM.

Present study has also an implication for the textbook writers. They can use all the principles and steps involved in developing SSM in preparing textbooks. They can also incorporate the self evaluation facility in the textbooks and assignments for the development of higher mental abilities among the school children.

In the light of the conclusion that teaching through SSM is significantly better than the traditional face-to-face approach to teach General Science to Class IX students, the important implications for the practitioners and planners is that they might consider teaching General Science to Class IX students through distance mode.

Though on the basis of this micro study no theory can be built , yet as an empirical study in the area of self-learning strategy, the findings of this study do add to the already existing findings that lend support to the theory of autonomy and independence (Wedmeyer,1977) and self-direction (Moore,1983) in learning. Besides, the empirical evidence produced by this study can be considered as a small addition towards establishing the effectiveness of the SSM over traditional teaching method. In this way, the findings of this study are a small contribution in the process of generalisation in this area.

Suggestions for Further Research

(i) The present study has been conducted only on a segment of general science syllabus of SEBA. More studies maybe conducted on different population and larger portions of the total curriculum before making any generalisation regarding the effectiveness of SSM.

(ii) SSM should be developed on other disciplines, like language, social science, mathematics, and the effect of different instructional materials on learning should be studied.

(iii) In the present study, the SSM is compared with traditional method. It may-be compared with other teaching materials/methods. It can also be used with other techniques.

(iv) The effectiveness of SSM could be studied on other relevant variables such as age, personality, and school climate.

(v) As the sample of the study consisted of only 58 school students, it is not enough to produce dependable knowledge in a generalised way. Hence this study can be replicated on a relatively larger sample for establishing the correctness of the results in order to arrive at more dependable knowledge.

(vi) The economic viability of SSM against traditional method adopted for teaching General Science to Class IX students could also be studied.

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