EFFECTIVENESS OF INSTRUCTIONAL STRATEGIES BASED ON GAGNE'S INSTRUCTIONAL DESIGN (ID) IN IMPROVING THINKING SKILLS OF SECONDARY SCHOOL STUDENTS

By

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ABSTRACT

The study was aimed at evaluating the effectiveness of Instructional Strategies based on Gagne's Instructional Design and Conventional Strategies of teaching science in improving the Thinking Skills of secondary school students. The seven Thinking Skills suggested by Raths, Louis (1967) namely, Observation, Comparison, Classification, Summarization, Interpretation, Inference and Evaluation were considered. The Pre-test and Post-test Parallel Group, T x L (Treatments x Levels) design was used. A self made Thinking Skills test was used to collect the data from the sample consisting of 96 students studying in standard Eight. Findings of this research revealed that; i) Instructional Strategies based on Gagne's Instructional Design when compared to that of Conventional Strategies of teaching is significantly effective in improving the Thinking Skills as a Whole and its sub skills namely, Comparison, Summarization, Interpretation, Inference, and Evaluation. ii) Above Average performed significantly better than Average and Average performed significantly better than Below Average in Thinking Skills as a Whole. iii) All the students and at all the three levels, namely, Above Average, Average and Below Average sustained the Thinking Skills improved through Instructional Strategies based on Gagne's Instructional Design. This study has made an attempt to infuse Thinking Skills into the existing curriculum through Instructional Strategies based on Gagne's Instructional Design. It has implications for the design and development of Instructional Materials in line with Gagne's Instructional Design to achieve different learning outcomes. It has been found to be a systematic strategy to improve classroom instruction across various disciplines and hence its inclusion in the teacher education curriculum will be a major step in making its application possible at the grass root level.

Keywords: Gagne's Instructional Design, Thinking Skills.

INTRODUCTION

In this age of Information and Communication Technology knowledge is expanding exponentially. It is difficult to keep up with this phenomenon. The rate at which knowledge today gets obsolete is very high compared to that of the past, it is essential that the emphasis of education should be on the development of abilities and dispositions of mind rather than merely the transfer of subject matter. The present century jobs demand more and more advanced skills of reasoning, thinking making decisions, and solving varied problems. Are the strategies used by teachers in the present classrooms equipping the students with these abilities? The answer probably is not to a great extent. Hence, research in education should be addressed to the problem of developing the required abilities in the students. In order to develop these abilities in the students Instructional programmes provided should be well planned, effectively implemented and evaluated. Research indicates that critical thinking and problem solving skills are not typically addressed in the classroom by the teachers using Conventional Strategies. The Conventional Strategies are teacher centered, textbook oriented, examination centered, chalk and talk dominated. A number of studies indicate that 85% of teacher questions are at the recall or simple comprehension level. Questions that elicit synthesis and evaluative skills of thinking are rarely asked. On the other hand researchers have been making efforts to develop instructional strategies to take care of these

inadequacies.

The effectiveness of any instructional programme or material depends upon appropriate planning or designing, what is called in professional parlance, Instructional Design (ID). ID is a systematic approach to design instruction and instructional materials to achieve specified learning objectives. Robert Gagne has been a central figure in the "creation" of the domain of ID. There has been a substantial effort by previous researchers to apply Gagne's Instructional Design as a training strategy in various fields. In our country where there is hardly infrastructure available to cater to individualized instruction, Gagne's Instructional Design would be a boon, that can be used at the group, tutorial and individualized learning levels to learn concepts, principles and Problem Solving and in turn develop Thinking Skills.

Research studies reviewed on Gagne's Instructional Design indicates that it is undoubtedly an effective training strategy that can enhance student learning. Though there are many instructional intervention programmes developed and used, they have not been researched thoroughly for its effectiveness.

Review of related literature

Gagne's Instructional Design has been extensively used in training modules in different disciplines such as Bioinformatics (Shachak, Aviv, et al., 2005), Mathematics (House, J. Daniel, 2002; Hashim, Yusup and Tik, Chan Chang , 1997) , Science (Geiger, Emily ,1990) , Physics (Simha, Sameera, K.S., 2000) and English as a Second Language (Medina, Suzanne, 1990). These researchers have also attempted to incorporate Gagne's nine events of instruction for classroom instruction (Shachak, Aviv, et al., 2005; House, J. Daniel, 2002; Hashim, Yusup and Tik, Chan Chang, 1997; Geiger, Emily, 1990; Medina, Suzanne,1990). Simha, Sameera, K.S. (2000) in his study on Using the Instructional model based on Robert Gagne's Theory of learning for classroom Instruction has found that the learning environment provided by the use of this instructional model has promoted the Problem Solving Skills in Physics among Secondary School students.

Leat, David, et al. (2005) in their study involved a group of teachers and lecturers in geographical education from northeast England in developing successful strategies to stimulate pupils' thinking skills. The study showed that after the in-service training most Dutch geography teachers appreciated the thinking skills strategies as a good way to stimulate students' and their own learning. Collier, Karen, et al. (2002) in a study attempted the use of Variety of Instructional Strategies for developing Critical Thinking Skills. Post-intervention data revealed definite improvements in student critical thinking skills for most students in the early childhood, kindergarten, and eighth-grade classes.

From the synthesis of the reviewed studies on strategies to improve Thinking Skills it is found that the main division in the field is between those who aim to teach thinking skills through specially designed programmes and those who favour the infusion of thinking through the established curriculum. Specially designed Programmes are usually based on analysis of component skills in thinking, which are taught and practised in special courses. The main criticisms of this approach is that it treats thinking as an 'add-on' element, that the skills approach is 'reductionist" or fragmentary, and that transfer of these skills to new contexts is by no means guaranteed. Those who favour infusion argue that thinking cannot and should not be separated from its context that this approach is more readily incorporated into current practice, and that transfer is more likely if thinking is embedded in all teaching and learning. In the past decade the infusion approach has come to be accepted more widely.

The attempt to apply Gagne's Instructional Design, in improving Thinking Skills through its infusion in the established curriculum has been neglected to a great extent. An effort in this direction is made in the present study to improve student learning in terms of Thinking Skills.

Present study

Gagne's Approach to ID includes three major aspects, namely, nine events of instruction, conditions of learning and learning outcomes. It includes the following:

Analyzing the requirements for learning

1.   Identifying the types of learning outcomes to be

achieved.

2. Each learning outcome is broken down into a hierarchy of dependent learning outcomes and pre-requirements to give a learning hierarchy of simple outcomes.

3. Identifying the internal conditions or processes of the learner that must occur to achieve the outcomes.

4. Specifying the external conditions or instruction that must occur to achieve the internal conditions.

Selecting media

5. Recording the learning context.

6. Recording the characteristics of the learners.

7. Select media for instruction

Designing Instruction

8. Planning to motivate the learner by incentives, task mastery or achievements.

9. For each of the planned learning outcomes in the learning hierarchy, the Nine Instructional Events are designed relevant to the type of learning outcomes required, in the order of pre-requirements in the learning hierarchy, and with appropriate media and use of tutors.

10. Tested in trials with learners (formative evaluation).

11. After the instruction has been used, a summative evaluation is used to judge its effectiveness.

In the present study, Instructional Strategies based on Gagne's ID produces an analysis of the learning to be accomplished in 1 to 6 and then translates this into a design for instructional events which will prompt and support the internal processes of the learner in 7 to 9. These are then tested, used and evaluated in 10 to 11. Gagne's theory is easy for teachers to use because it incorporates various types of learning theories. A teacher would determine which outcome he/she is trying to reach and then provide the associated learning conditions. A teacher following Gagne's theory would give frequent written and oral tests to students to gauge their understanding of the desired concept or skill. "Extensive testing is an essential feature of Gagne's learning hierarchy theory since learning is viewed as being cumulative" (Strauss, 1972, p. 74).

To what extent Instructional Strategies based on Gagne's ID bring about improvement in the Thinking skills of students? This was the major research question of the study. Thinking skills were considered as activities that elicit Thinking. The Thinking Skills (Operations) suggested by Raths (1967) namely; Observation, Comparison, Classification, Summarization, Interpretation, Inference and Evaluation relevant and applicable to science instruction were considered in the present study. An attempt is made in the present study to apply Gagne's Instructional Design in improving Thinking Skills through its infusion in the established curriculum.

Objectives

- To compare the effectiveness of Instructional Strategies based on Gagne's Instructional Design and Conventional Strategies in improving Thinking Skills as a Whole and in terms of its sub-skills of Secondary School students.

- To find the effectiveness of Instructional Strategies based on Gagne's Instructional Design and Conventional Strategies in improving Thinking Skills as a Whole and in terms of its sub-skills of Above Average, Average and Below Average levels of students (determined on the basis of Intellectual Capacity).

- To study the interaction between 'treatments' and 'levels of students' in improving Thinking Skills as a Whole and in terms of its sub-skills of Secondary School students.

- To find out whether the students Sustained the Thinking Skills improved through the Instructional Strategies based on Gagne's Instructional Design.

Hypotheses

Thinking Skills as a Whole

H_1: Instructional strategies based on Gagne's Instructional Design are more effective than the Conventional Strategies of teaching Science in improving Thinking Skills as a Whole.

H_2: The Above Average, Average and Below Average

levels of students taught through Instructional strategies based on Gagne's Instructional Design and Conventional Strategies differ in improving Thinking Skills as a Whole.

H_3: There is an interaction between 'treatments' and 'levels of students' with reference to improving Thinking Skills as a Whole.

Sub-Skills of Thinking: A total of twenty one hypotheses, three pertaining to each of the sub-skills of thinking as above were formulated.

Treatment effect on the Sustained Thinking Skills:

H_4: Immediate and delayed Post-test scores of the group taught through Instructional strategies based on Gagne's Instructional Design differ significantly with reference to Thinking Skills.

H_5: Immediate and delayed Post-test scores of the group taught through Instructional strategies based on Gagne's Instructional Design differ significantly with reference to Thinking Skills of Above Average students.

H_6: Immediate and delayed Post-test scores of the group taught through Instructional strategies based on Gagne's Instructional Design differ significantly with reference to Thinking Skills of Average students.

H_7: Immediate and delayed Post-test scores of the group taught through Instructional strategies based on Gagne's Instructional Design differ significantly with reference to Thinking Skills of below Average students.

Methodology

Research Design

The Pre-test and Post-test Parallel Group (T x L) Design was used in the study. This is diagrammatically represented in Table1.

Sample

The sample consisted of 96 students within the age group 13 to 15 studying in Standard Eight. Based on their intellectual capacity 'T' Scores, matched pairs were identified and distributed into two groups as Experimental and Control groups with 48 cases in each group. Each group was further divided into 3 levels as Above Average, Average and Below Average consisting of 16 students at each level based on their intellectual capacity 'T' Scores.

| Treatments | Levels | | |
	L1 (Above Average)	L2 (Average)	L3 (Below Average)
Treatments	T_1 Instructional Strategies based on Gagne's Instructional Design	n T_1L_1	n T_1L_2	n T_1L_3
	T_2 Conventional Strategies	n T_2L_1	n T_2L_2	n T_3L_3

Table 1. Schematic Representation of Treatments and Levels

Tool used

The data for the present study was collected using the Thinking Skills test developed by the investigators. It consisted of 42 items. There were 6 items under each of the Thinking Skills namely; Observation, Comparison, Classification, Summarization, Interpretation, Inference and Evaluation. The content validity was established by expert rating. The coefficient of consistency by the Split-Half method was found to be 0.89. The Concurrent Validity co-efficient of 0.73 was found against the external criterion, the test of Basic Process Skills (BPS) developed by Michael. j. Padilla, et al.

Procedure of the study

In order to avoid the inter-personal and intra-personal variation of two different teachers for Instructional strategies based on Gagne's ID and Conventional strategies groups, it was decided to conduct both the classes by a single teacher having competence in both the strategies on the same dates. The two groups were pre-tested on Thinking Skills. The experimental treatment involved the teaching of a selected unit in Science, namely, "Light" involving six defined Concepts, four Principles and four Problems comprehensively covering the whole unit in Physics for the students of Standard Eight. Each lesson was of one and half hour duration. A total of fourteen lessons were taught by using Instructional strategies based on Gagne's Instructional design to the experimental group of students. Each lesson was taught following the nine external instructional events in order to initiate the activity of the internal learning process as

suggested by Gagne. Each lesson had a formative evaluation in the form of written test, deliberately planned and implemented by the researcher. At the end of all the lessons a Summative written test was done. Mean while, the other group of students were taught the same lessons on the same day for the same duration of time by the same teacher using Conventional Strategies of teaching science. Immediately after the completion of the treatment, both the groups were Post-tested on Thinking Skills. After such a treatment the students continued their schooling and at the end of four weeks another delayed Post-testing was done using the same tool to know the retention of the Thinking Skills by the students in the experimental group as a result of the treatment.

Limitations and Delimitations

- Instructional Strategies based on Gagne's Instructional Design can be applied to any subject, at any level. In the present study, the background of the Researcher has enabled its application to Physics Instruction in Science at Secondary School level.

- Instructional strategies based on Gagne's Instructional design can be applied for different types of Instruction viz., Group, Tutorial and Individualized. In the present study, it is applied to Group Instruction as it is suitable to the Indian context.

- Two major categories of learning outcomes, namely, Intellectual Skills - Concept & Principle Learning; and Cognitive strategy Problem Solving were considered in the study.

- The study was confined to the Teaching of Science for Standard Eight students only.

- Selected Major Thinking Skills relevant at the Secondary School level, namely, Observation, Comparison, Classification, Summarization, Interpretation, Inference, and Evaluation were considered in evaluating the effectiveness of Instructional Strategies based on Gagne's Instructional Design.

Results

The objectives 1, 2 and 3 and the related hypotheses were tested by applying 't' test for non-independent

samples , Hartley's F_{max} test of Homogeneity, 2-way Analysis of Variance and Scheffe's test for multiple comparison of means. The results are given below:

Thinking Skills as a whole

Table 2 gives the summary of Analysis of Variance pertaining to Thinking Skills as a Whole.

On the basis of the above analysis it can be concluded that the Instructional Strategies based on Gagne's Instructional Design when compared to that of Conventional Strategies of teaching Science is significantly more effective in improving the Thinking Skills as a Whole of Standard Eight students. The performance on Thinking Skills as a Whole of Standard Eight students revealed that, Above Average performed significantly better than Average and Average performed significantly better than Below Average. The difference between Instructional Strategies based on Gagne's Instructional Design and Conventional Strategies of teaching Science is independent of the levels (Above Average, Average and Below Average) of students of Standard Eight in improving Thinking Skills as a Whole.

Thinking Skill of Observation

Table 3 gives the summary of Analysis of Variance pertaining to Thinking Skill of Observation.

On the basis of the above analysis it can be concluded that the Instructional Strategies based on Gagne's

Sources of Variation	df	SS	MS (SS/df)	F	Significance P<0.05
Treatments (A)	1	133.01	133.01	96.38	YES
Levels(B)	2	29.77	14.89	10.79	YES
Interaction (A X B)	2	5.14	2.57	1.86	NS
Within Groups (Error)	90	124.07	1.38		
Total	95	291.99			

NS Not Significant

Table 2. Summary Table of ANOVA Pertaining to Thinking Skills as a Whole

Sources of Variation	df	SS	MS (SS/df)	F	Significance P<0.05
Treatments (A)	1	0.51	0.51	2.11	NS
Levels (B)	2	0.03	0.015	0.043	NS
Interaction (A x B)	2	0.13	0.065	0.301	NS
Within Groups (Error)	90	21.81	0.24		
Total	95				

Table 3. Summary Table of ANOVA Pertaining to Thinking Skill of Observation

Instructional Design when compared to that of Conventional Strategies of teaching Science did not differ significantly in improving the Thinking Skill of Observation of students. There is no difference in the performance on Thinking Skill of Observation of Above Average, Average and Below Average students. The difference between Instructional Strategies based on Gagne's Instructional Design and Conventional Strategies of teaching Science, is independent of the levels (Above Average, Average and Below Average) of students in improving Thinking Skill of Observation. From these findings it is inferred that, Instructional Strategies are not related to improving Thinking Skill of Observation at all the three levels of students, and there is no interaction.

Thinking Skill of Comparison

Table 4 gives the summary of Analysis of Variance pertaining to Thinking Skill of Comparison.

On the basis of the above analysis it can be concluded that the Instructional Strategies based on Gagne's Instructional Design when compared to that of Conventional Strategies of teaching Science is significantly more effective in improving the Thinking Skill of Comparison of students. There is no difference in the performance on Thinking Skill of Comparison of Above Average, Average and Below Average students. The difference between Instructional Strategies based on Gagne's Instructional Design and Conventional Strategies of teaching Science, is dependent on the levels (Above Average, Average and Below Average) of students in improving Thinking Skill of Comparison. From these findings it is inferred that, Instructional Strategies are related to improving Thinking Skill of Comparison, but the kind of relation depends on levels of students.

The interaction between 'treatments' and 'levels' of

students is significant. In other words, when 'treatments' and 'levels' of students are allowed to interact, they are significantly effective. This signifies that, treatments differ in their effectiveness depending upon students' levels. Further application of Scheffe's test lead to the following findings; As a result of treatment through Instructional Strategies based on Gagne's Instructional Design, Above average students have benefited maximally when compared to Average and Below Average students, Below Average students are moderately benefited when compared to the Above Average and Average students, and Average students are the least beneficiaries, when compared to the Above Average and Below Average students in the improvement of Thinking Skill of Comparison. All the three level (Above Average, Average and Below Average) groups have been benefited by the treatment when compared to that of Conventional Strategies of teaching science in the improvement of Thinking Skill of Comparison.

Thinking Skill of Classification

Table 5 gives the summary of Analysis of Variance pertaining to Thinking Skill of Classification.

On the basis of the above analysis it can be concluded that the Instructional Strategies based on Gagne's Instructional Design when compared to that of Conventional Strategies of teaching Science did not differ significantly in improving the Thinking Skill of Classification of students. There is no difference in the performance on Thinking Skill of Classification of Above Average, Average and Below Average students. The difference between Instructional Strategies based on Gagne's Instructional Design and Conventional Strategies of teaching Science, is independent of the levels (Above Average, Average and Below Average) of students in improving Thinking Skill

Sources of variation	df	SS	MS (SS/df)	F	Significance P<0.05
Treatments (A)	1	7.04	7.04	10.76	YES
Level (B)	2	1.08	0.54	0.83	NS
Interaction	2	4.33	2.17	3.31	YES
(A X B)	90	58.88	0.65		
Within Groups (Error)					
Total	95				

Table 4. Summary Table of ANOVA pertaining to Thinking Skill of Comparison

Sources of variation	df	SS	MS (SS/df)	F	Significance P<0.05
Treatments(A)	1	0.38	0.38	0.799	NS
Level(B)	2	0.06	0.031	0.067	NS
Interaction	2	1.313	0.066	1.398	NS
(A X B)	90	42.25	0.469		
Within Groups (Error)					
Total	95				

Table 5 : Summary Table of ANOVA Pertaining to Thinking Skill of Classification

of Classification. From these findings it can be inferred that, Instructional Strategies are not related to improving Thinking Skill of Classification at all the three levels of students, and there is no interaction.

Thinking Skill of Summarization

Table 6 gives the summary of Analysis of Variance pertaining to Thinking Skill of Summarization.

On the basis of the above analysis it can be concluded that the Instructional Strategies based on Gagne's Instructional Design when compared to that of Conventional Strategies of teaching Science is significantly more effective in improving the Thinking Skill of Summarization of students. The performance of Average students was significantly better than the Above Average and Below Average students on Thinking Skill of Summarization. The difference between Instructional Strategies based on Gagne's Instructional Design and Conventional Strategies of teaching Science is independent of the levels (Above Average, Average and Below Average) of students in improving Thinking Skill of Summarization. From these above findings it is inferred that, Instructional Strategies are related to improving Thinking Skill of Summarization at all the three levels of students, however there is no interaction.

Thinking Skill of Interpretation

Table 7 gives the summary of Analysis of Variance pertaining to Thinking Skills of Interpretation.

On the basis of the above analysis it can be concluded that the Instructional Strategies based on Gagne's Instructional Design when compared to that of Conventional strategies of teaching Science is significantly more effective in improving the Thinking Skill of Interpretation of students. The performance on Thinking Skill of Interpretation of students revealed that Above

Sources of Variation	df	SS	MS (SS/df)	F	Significance P<0.05
Treatments (A)	1	3.38	3.38	6.01	YES
Level (B)	2	8.33	4.17	7.43	YES
Interaction (A X B)	2	1.75	0.88	1.56	NS
Within Groups (Error)	90	50.5	0.56		
Total	95				

Table 6 Summary Table of ANOVA Pertaining to Thinking Skill of Summarization

Sources of Variation	df	SS	MS (SS/df)	F	Significance P<0.05
Treatments (A)	1	7.04	7.04	14.49	YES
Level (B)	2	4.19	2.09	4.31	YES
Interaction (A X B)	2	1.65	0.82	1.69	NS
Within Groups (Error)	90	43.75	0.486		
Total	95				

Table 7. Summary Table of ANOVA pertaining to Thinking Skill of Interpretation

Average performed significantly better than Average and Average performed significantly better than Below Average. The difference between Instructional Strategies based on Gagne's Instructional Design and Conventional Strategies of teaching Science is independent of the levels (Above Average, Average and Below Average) of students in improving Thinking Skill of Interpretation. From these above findings it is inferred that, Instructional Strategies are related to improving Thinking Skill of Interpretation at all the three levels of students, however there is no interaction.

Thinking Skill of Inference

The following Table 8 gives the summary of Analysis of Variance pertaining to Thinking Skill of Inference.

On the basis of the above analysis it can be concluded that the Instructional Strategies based on Gagne's Instructional Design when compared to that of Conventional Strategies of teaching Science is significantly more effective in improving the Thinking Skill of Inference of students. There is no difference in the performance on Thinking Skill of Inference of Above Average, Average and Below Average students. The difference between Instructional Strategies based on Gagne's Instructional Design and Conventional Strategies of teaching Science, is independent of the levels (Above Average, Average and Below Average) of students in

Sources of Variation	df	SS	MS (SS/df)	F	Significance P<0.05
Treatments (A)	1	4.59	4.59	8.56	YES
Level (B)	2	2.90	1.45	2.70	NS
Interaction (A X B)	2	0.44	0.22	0.41	NS
Within Groups (Error)	90	48.31	0.54		
Total	95				

Table 8. Summary Table of ANOVA Pertaining to Thinking Skill of Inference

improving Thinking Skill of Inference. From these findings it is inferred that, Instructional Strategies are related to improving Thinking Skill of Inference regardless of the three levels of students and there is no interaction.

Thinking Skill of Evaluation

Table 9 gives the summary of Analysis of Variance pertaining to Thinking Skill of Evaluation

On the basis of the above analysis it can be concluded that the Instructional Strategies based on Gagne's Instructional Design when compared to that of Conventional Strategies of teaching Science is significantly more effective in improving the Thinking Skill of Evaluation of students. There is no difference in the performance on Thinking Skill of Evaluation of Above Average, Average and Below Average students. The difference between Instructional Strategies based on Gagne's Instructional Design and Conventional Strategies of teaching Science, is independent of the levels (Above Average, Average and Below Average) of students in improving Thinking Skill of Evaluation. From these above findings it is inferred that, Instructional Strategies are related to improving Thinking Skill of Evaluation regardless of the three levels of students and there is no interaction.

Sustained Thinking Skills

From the findings of the above analysis, it is clear that Instructional Strategies based on Gagne's Instructional Design applied to science teaching is more effective when compared to the Conventional Strategies of teaching Science in terms of improvement of Thinking Skills among students of Standard VIII. Further, the researcher intends to test whether the effects resulted from this treatment are sustained by the students. The data collected from the immediate post-test and delayed post test are analyzed and are presented in

Sources of Variation	df	SS	MS (SS/df)	F	Significance P<0.05
Treatments (A)	1	12.04	12.04	18.49	YES
Level (B)	2	3.25	1.63	2.49	NS
Interaction (A X B)	2	2.58	1.29	1.98	NS
Within Groups (Error)	90	58.63	0.65		
Total	95				

Table 9. Summary Table of ANOVA Pertaining to Thinking Skill of Evaluation

Table10.

The findings of objective 4 are given below:

The Table 10 shows that immediate post-test and delayed post-test scores of Experimental group do not differ significantly with regard to Thinking Skills. Therefore, it can be concluded that the students in the experimental group sustained the Thinking Skills improved through Instructional Strategies based on Gagne's Instructional Design.

Further, the researcher intended to test whether the effects resulted from this treatment is sustained by all the three levels of students, namely, Above Average (level I), Average (level II) & Below Average (level III). The findings are given in the Table 11.

Gagne's Instructional Design and Thinking Skills

The Table 11 shows that immediate post-test and delayed post-test scores of all the three levels, namely, Above Average, Average and Below Average students of Experimental group do not differ significantly with regard to sustaining Thinking Skills as a whole. Therefore, it can be concluded that all the three levels, namely, Above Average, Average and Below Average students in experimental group have sustained the Thinking Skills improved through Instructional Strategies based on Gagne's Instructional Design.

Major Findings

The major findings of the present study are as follows:

(i) Instructional Strategies based on Gagne's Instructional Design when compared to that of

Dependent Variable	ΣD	ΣD^2	Obtained 't' Value	Theoretical Value	Significance P<0.01
Thinking Skills	-20	98	2.09	2.69	NS

Table 10. Sum of Immediate Post-test and Delayed Post-test difference scores and 't' value with its significance on Sustained Thinking Skills <n=48>

Levels	ΣD	ΣD^2	Obtained 't' Value	Theoretical Value	Significance P<0.01
Level I (Above Average)	-3	17	0.72	2.95	NS
Level II (Average)	-12	52	1.77	2.95	NS
Level III (Below Average)	-5	29	0.92	2.95	NS

Table 11. Sum of Post-test and Delayed Post-test difference scores with their significance on Sustained Thinking Skills at different levels of students <n=16>

Conventional Strategies of teaching science to students at secondary school level is significantly more effective in improving,

- Thinking Skills as a Whole

- Thinking Skill of Comparison

- Thinking Skill of Summarization

- Thinking Skill of Interpretation

- Thinking Skill of Inference, and

- Thinking Skill of Evaluation.

(ii) The performance of students in

- *Thinking Skills as a Whole:* Above Average performed significantly better than Average and Average performed significantly better than Below Average.

- *Thinking Skill of Summarization:* Average performed significantly better than the Above Average and Below Average.

- *Thinking Skill of Interpretation:* Above Average performed significantly better than Average and Average performed significantly better than Below Average.

(iii) The difference between Instructional Strategies based on Gagne's Instructional Design and onventional Strategies of teaching Science, is dependent on the levels of students in improving Thinking Skill of Comparison.

- Above Average students instructed through Instructional Strategies based on Gagne's Instructional Design applied to science teaching have improved significantly better in Thinking Skill of Comparison than those Above Average taught through Conventional Strategies of teaching Science.

- Above Average students instructed through Instructional Strategies based on Gagne's Instructional Design as applied to science teaching have improved significantly better in the Thinking Skill of Comparison than those of Average students.

(Iv) All the students and at all the three levels, namely,

Above Average, Average and Below Average have sustained the Thinking Skills improved through Instructional Strategies based on Gagne's Instructional Design.

Discussion

The study has shown that Infused Thinking Skills instruction using Instructional Strategies based on Gagne's Instructional Design leads to improved Thinking Skills in students. It is found to be better than Conventional Strategies in improving Thinking Skills of students. Hence, the study implies that the Instructional Strategies based on Gagne's Instructional Design should be used in the teaching of science to students at secondary school level especially to improve their Thinking Skills, and sub-skills namely, Thinking Skill of Comparison, Summarization, Interpretation, Inference, and Evaluation.

It is also found that Thinking Skill of Comparison can be best fostered in the Above Average students through Instructional Strategies based on Gagne's Instructional Design. This implies that it is an effective strategy for students with high intellectual ability to enhance thinking skills. The finding that, Average students are the least beneficiaries, when compared to the Above Average and Below Average students in the improvement of Thinking Skill of Comparison, is rather an unusual finding and the reason for this can be attributed to the treatment given involving Gagne's nine events of instruction which focused on every aspect of learning involving internal and external conditions for the learner to learn effectively. Gagne's Instructional Design provided innumerable opportunities to the learner in the form of 'learning guidance' , practice, feedback, review of the lesson etc. which would have been more advantageous to the Below Average students compared to that of Average students in acquiring the Thinking Skill of Comparison. Apart from this, the Below Average students might have taken all the opportunities provided in a patient and serious manner compared to that of Average students who might have got distracted and felt impatient to go through the whole procedure using Gagne's nine events of instruction. This might have brought down their ability in

the thinking skill of comparison, compared to that of Below Average students. However, to generalize the results further research has to be undertaken.

The finding that the Thinking Skills improved through Instructional Strategies based on Gagne's Instructional Design is sustained by all the three levels, namely, Above Average, Average and Below Average students, proves to be a strategy that can be relied upon in improving Thinking Skills of students.

However, the present study was limited only to Thinking Skills as dependent variable. The study applied Gagne's Instructional strategies only to Science discipline involving learning outcomes related to intellectual skills through group instruction. The investigators realized that, there is lot of scope for research in this area. The Future research should continue to focus on the following aspects:

- Instructional Strategies based on Gagne's Instructional Design can be tested for its effectiveness with the other learning outcomes namely, Verbal Information, Attitudes, and Psycho- motor skills.

- Instructional Strategies based on Gagne's Instructional Design can be tested for its effectiveness with the other dependent variables, namely, Achievement, Communication Skills, Creative Thinking Skills, Creative Problem Solving Skills, Learning of grammar, etc.

- The impact of Instructional Events in various instructional settings, namely, Individualized and tutorial can be tested.

- The effectiveness of Instructional Events to achieve the learning outcomes is not researched in disciplines like, Biology, Local Languages, and Computer Science, etc. An investigation can be undertaken in these disciplines.

- The Instructional Events can be thoroughly researched for its effectiveness in developing motivation and transfer ability in comparison with other Strategies.

- Research could also be done to examine how instructional events in computer-based instruction influence outcomes such as Problem solving and Complex Learning Tasks.

- Furthermore, the recent proliferation of web-based and Internet-based instruction suggests that studies should be conducted to examine the effect of objectives, examples, practice and review in these settings.

Thus, studies of this nature will continue to inform designers about the influence of Gagne's Instructional Events on learning and performance.

Conclusion

It is expected that the emphasis of education should be on the development of abilities and dispositions of mind rather than merely the transfer of subject matter. Education should aim at developing the required abilities in the students. The Conventional strategies used by teachers in the present classrooms are not focused on developing Thinking skills in students. The present study has proved that Gagne's ID strategies are better than Conventional strategies in improving the Thinking Skills of students. This study has implications for the design and development of Instructional Materials in line with Gagne's Instructional Design to achieve different learning outcomes. The Instructional Designers need to do a thorough Content Analysis and identify the learning outcomes prior to Instruction that helps in developing instructional plans in an effective manner to climb the ladder of learning hierarchy. It has been found to be a systematic strategy to improve classroom instruction across various disciplines and hence its inclusion in the teacher education curriculum will be a major step in making its application possible at the grass root level.

The wide application of this strategy is possible by providing necessary training to teachers in the use of this strategy. Though Gagne's events of instruction are known to secondary school teachers, they are not familiar with the strategies of infusing Thinking Skills through the established curriculum in their Instructional process. The teachers need sufficient training to use Gagne's

instructional design to improve thinking skills in their students. Efforts in this direction will surely bring in improvement in student performance.

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