Effect of Metacognitive Strategy On Jigsaw Cooperative Learning Method To Enhance Biology Achievement

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ABSTRACT

The purpose of this study was to determine how the adoption of metacognitive strategy in jigsaw cooperative learning method influences students' achievement in Biology. The study was carried out by following pre-test post-test experimental design with one control group and one experimental group. To guide this study, six hypotheses were stated and tested at 0.05 level of significance. A total of 70 students from Municipal Higher Secondary School, Tamilnadu, India were used as sample for the study. The tools Metacognitive Strategy Model on Achievement in Biology, Biology Achievement Test (BAT), Attitude Scale Towards Learning Biology (ASTLB) and Home Environment Inventory (HEI) were developed, validated and used. The results suggested that instruction in the metacognitive strategy improve the students' biology achievement.

Keywords: Metacognitive strategy; Jigsaw cooperative learning method; Achievement in Biology

INTRODUCTION

Biology is one of the major branches of science. There is an increasing impact of growing knowledge in the subject of biology on our social and economic life. A poor biology foundation at the higher secondary school will jeopardize any future effort to enhance achievement in the subject. The study of biology at the higher secondary school level helps students in developing basic skills, knowledge about their environment.

The poor achievement of learners in biology has been variously explained. The factors that negatively affect biology achievement include students' background problems; students' lack of interest and/or negative attitude towards biology; teacher related factors like poor teacher preparation; inadequate qualified biology teachers, inadequate instructional materials and application of poor teaching methods. Many students don't feel good about Biology, largely as a result of the way they have been taught.

Biology teachers mainly adopt instructional strategies that are mainly teacher directed and do not encourage deeper students involvement. In the conventional classroom, surface approaches to learning are very common. Most students adopted a surface approach to learn in terms of attending classes, reviewing notes and doing exercises. The students are the passive recipient of the information already acquired by the teacher. Most conventional biology classes aim to make mastery of the text-book, to complete text-book assignments and examination orientated. Since the students are taught using chalk and talk method, the students are not able to get aware of better knowledge in learning biology. Instead of viewing teaching as teacher exposition followed by students practice, effective teaching may be achieved by integrating a self-regulating strategy such as metacognitive assessment in the process. The constructivists approach to learning locates understanding within the learners, not with the teachers. It is the learners who must learn and therefore must take the responsibility for learning.

METACOGNITION

Metacognition refers to one's knowledge concerning one's own cognitive processes or anything related to them (Flavell, 1976). Quite simply, metacognition is thinking about thinking. Brown (1987) divides metacognition into two broad categories: Knowledge of cognition and regulation of cognition. Knowledge of cognition refers to activities that involve conscious reflection on one cognitive abilities and activities. Regulation of cognition refers to activities regarding self-regulatory mechanisms during an ongoing attempt to learn. Any process in which students examine the method that they are using to retrieve, develop or expand information is deemed to be metacognitive in nature.(Everson et.al.1998). Met cognitively aware learners "know what to do when they don't know what to do"

(Countinbo, 2007). In other words, they have strategies for discovering or working out what needs to be done. Metacognitive strategies are designed to monitor cognitive process. Metacognitive strategies are ordered processes used to control one's own cognitive activities and to ensure that a cognitive goal has been met. A student with good metacognitive awareness oversees his own learning process, plan and monitor ongoing cognitive activities. The use of metacognitive strategies ignites one's thinking and can lead to better learning and higher performance, especially among learners who strive. Developing metacognitive instructions or questions about the topic at hand would be more challenging for the teacher. The teacher would have to change his/her mind-set and pose questions that truly require the teacher to analyze the existing links to other common experiences and material, determine which processes the student may possibly use, and formulate questions accordingly. Some of the questions that are posed during the discussion can be meaningful and multifaceted. Hartman (2001) states that teaching with metacognitive strategies means that teacher will think about how their instruction will activate and develop students' metacognition.

COOPERATIVE LEARNING

Bilgin, I.et.al.(2006), and Chang, C-Y., & Mao, S-L. (1999) in their contributions noted that cooperative learning activity engages the student in the learning process and seeks to improve the critical thinking, reasoning, and problem-solving skills of the learner. Stevens, R., & Slavin, R. (1995) stated that peer interaction is central to the success of cooperative learning as it relates to cognitive understanding. They further noted that comprehension is facilitated. They emphasized that as learners, some of who might normally "turn out" or refuse to speak out in a traditional setting, become actively involved in the learning process through group interaction. Chang.et.al (1999) noted that every cooperative-learning strategy, when used appropriately, can enable students to move beyond the text, memorization of basic facts, and learning lower level skills. This method which results in cognitive restructuring leads to an increase in understanding of all students in a cooperative group. Apart from academic benefits, cooperative learning has been found to promote self-esteem, interpersonal relationship and improved attitudes toward school and peers (Bilgin, I.et.al.2006). In the cooperative learning, students have the opportunity to discuss their answers with fellow students. The students could jot –down their answers to a question, turn to their neighbour and talk about their answers and sharing the same with the entire class. It forces student to discuss their thinking, analyze their position, and explain their point of view to their classmates. By their sharing information with the entire class, students would be able to evaluate themselves while gathering information from other classmates. The teacher would also have the opportunity to evaluate the students' understanding based on the content of the discussions.

METACOGNITIVE COOPERATIVE LEARNING METHOD

Learning process in learner centered approach is characterized by cooperative and collaborative learning environments. The two methods compared in this experiment are – (i) Metacognitive cooperative learning method and (ii) Traditional method. Piaget calls operation when children are able to engage themselves in activities. Bruner, Gandhi and Pestalozzi have also stressed learning by doing. In activity based learning teachers provide environment for activities which are relevant to the subject matter. Cooperative Learning is an answer to the defects of competitive learning. Today teachers need an instructional technique which is of low cost and which does not demand hard work, so that they could love the subject and be more efficient in their teaching. Metacognitive knowledge of people is an important concept for the classroom. Metacognitive knowledge of tasks operates when the nature of task forces us to think about how we will manage. In the similar manner Cooperative Learning refers to an Instructional Technique in which pupils study in small groups and are rewarded some way for performance as a group. This strategy based on the psychology of cooperation and competition among pupils in the class. Here pupils are to work together for a common goal, motivating themselves by depending on others, encouraging each other‟s during the task of learning and by increasing positive contact among the group members. So metacognitive cooperative learning method will result in better classroom performance. In this context metacognitive cooperative learning method is very useful and can be adapted by any teacher easily. Since learning strategies can be taught, we can help our pupils to concentrate on just what they do, when they learn. With this theoretical background a research study was conducted to study the effectiveness of metacognitive cooperative Learning method on the Achievement in Biology.

Home is considered as a first school for every individual and it is one of the basic elements in the society. Hence the environment of home plays vital role on the development of every individual in sociological perspectives. The performance and the achievement of every child depend on the environment given by the parents at home to their wards. Considering the importance of the environment of home, the present study has included *"Home Environment"* as one of the influencing sociological factor.

Attitude plays a vital role among individuals. To create interest towards learning, attitude has its own role. If the attitude is positive, there will be better learning takes place otherwise there will not be a chance of learning. Hence attitude towards learning any concept or subject plays significant role. Therefore the present study has included another psychological factor .i.e. *Attitude Towards Learning Biology among higher secondary students.*

The study aims to measure the achievement of higher secondary students in biology, using metacognitive-Cooperative learning method with home environment as sociological factor, attitude on learning biology as psychological factor and metacognitive awareness as cognitive factor. Hence, the study not only concentrates on developing the metacognitive strategies in cooperative learning approach and its effectives, but also aims to study the intervening factors of learning biology among higher secondary students.

OBJECTIVES

This study was guided by the following objectives.

i. To develop a metacognitive strategy model in Biology for standard XI students.

ii. To find whether there is any significant difference between control group and experimental group in gain scores of higher secondary students.

iii. To find whether there is any significant difference between control group and experimental group in gain scores on attainment of objectives: knowledge, understanding and application of higher secondary of students.

iv. To find whether there is any significant difference between control group and experimental group in retention test scores of higher secondary students.

v. To find whether there is any significant influence of home environment on gain scores of control group and experimental group.

vi. To find whether there is any significant influence of metacognitive awareness on gain scores of control group and experimental group.

vii. To find whether there is any significant influence of attitude towards learning biology on gain scores of control group and experimental group.

HYPOTHESES

Six hypotheses were stated and tested at 0.05level of significance.

i. There is no significant difference between control group and experimental group in gain scores of higher secondary students.

ii. There is no significant difference between control group and experimental group in gain scores on attainment of objectives: knowledge, understanding and application of higher secondary of students.

iii. There is no significant difference between control group and experimental group in retention test scores of higher secondary students.

iv. There is no significant influence of home environment on gain scores of control group and experimental group.

v. There is no significant influence of metacognitive awareness on gain scores of control group and experimental group.

vi. There is no significant influence of attitude towards learning biology on gain scores of control group and experimental group.

METHODOLOGY

Design of the Study

The design selected for the present study is Pre-test Post-test Equivalent – Groups Design with one experimental group and one control group.

Population and Sample of the Study

The test population consisted of 400 higher secondary class students in Municipal Higher Secondary School, Tirunelveli, India. A total of 70 students studying standard XI constituted the total sample. The sample was randomly selected. *Catell's Culture Fair Intelligence Test* was conducted to split the sample into two equivalent groups. Based on the intelligent test score, they were categorized into Experimental group and Control group. A set of two individuals with identical or nearly identical intelligent test scores were selected and assigning one of them to experimental group and another one to control group. So there were 35 students in each group. To ensure the homogeneity of the group, the 't' test was conducted and there is no significant difference between experimental group and control group . Hence the two groups are equivalent.

TOOLS FOR THE STUDY

Metacognitive strategy model on achievement in biology

Biology syllabus at higher secondary level was analyzed. Textbooks, handbooks, reference books, method of teaching, examination system, pedagogical principles, etc., also were analyzed. Consultations with experts in the field of school education, metacognition and teacher education were made for framing the sequence of learning events. Teaching techniques, Metacognitive strategies and its process were identified to enhance achievement in biology of higher secondary students.

The metacognitive strategy were designed on the basis of the four steps i) Identifying teaching techniques ii) Identifying metacognitive dimensions iii) Process to develop metacognitive behaviours and iv) Validation.

i) Identifying Teaching Techniques

Metacognitive environment can be created in Inquiry, Cooperative learning and Problem solving. In the present study, jigsaw cooperative learning method was used for creating metacognitive environment among higher secondary students.

ii) Identifying Metacognitive dimensions

After having gone through the various dimensions suggested by the researchers in literature, the metacognitive strategies for the following dimensions are framed. They are i) Meta-memory ii) Self-planning iii) Self-monitoring iv) Self-evaluation and v) Self-regulation

iii) Process to Develop Metacognitive Behaviours

The process to develop metacognitive behaviours proposed by *Blakey and Spence (1990)* was adopted in the present study. The steps in process stage are "Define what you know and what you do not know", "Talk about what you are thinking", "Keeping a diary of thinking", "Planning and self-control", "Thinking process briefing", "Self-assessment".

Step1. Define what you know and what you do not know:

Students determine their levels by asking themselves 'What is my relevant information about the subject?' What do I know? What do I want to learn? What do I not know?

Step2. Talk about what you are thinking: This includes the loud thinking in the process of making plan or problem solving. This study can be performed in peer groups or in small groups, that one student assumes the role of a teacher. These students talk and ask questions by telling and making explanations and abstraction.

Step3. Keeping a diary of thinking: Another way of developing awareness of cognitive thinking is to keep a diary. Students can write difficulties and their interpretations about problems in that notebook. They also note the process and methods used to solve the problem. Thus, students have the idea about experience and methods of thinking.

Step4. Planning and self-control: It is students' plan to control the process that is relevant to the subject that is going to be learnt. However, students must have earned some characteristics in advance such as adjusting time, identifying and using materials.

Step5. Thinking process briefing: This strategy covers, develops and uses the metacognitive and thinking skills that the students acquired. It involves a three-step method. Primarily, the teacher needs to guide the students about how they gained information by thinking in class and how they took part in activities. In the next stage, students need to group ideas and define which thinking strategies they used, and in the final stage, students should evaluate their own achievements and make assessments about their election in relation to future strategies.

Step6. Self-assessment: It is the determination of the metacognitive skills of the students by the pre-prepared individual checklist in the form of assessment. Metacognitive strategies are the sequential processes used to provide control in learning and in reaching one's goal. They help individuals significantly to make regulations and take control of their learning. For example, after reading a text, a student can query himself about the concepts discussed in the paragraph. This self-evaluation is a monitoring metacognitive strategy and at this stage, the cognitive purpose of students is to understand texts. If a student fails to answer his own question, he must determine what he needs to perform his cognitive purpose which is to understand the text. In order for him to answer his own question satisfactorily, for example, he may decide to read the paragraph again. After reading the text again, if he can answer the question, he may be able to understand the subject. Thus, the metacognitive strategy of self-evaluation would be fulfilled by the comprehension which is the aim of cognitive skills.

During the execution of steps from step1 to step 6, a work sheet containing metacognitive statements is given

to all the students for reference. Students were asked to refer the statements in worksheet in the classroom.

iv)Validation

It was given to the experts in the field of metacognition for opinion. The metacognitive strategies were thus modified according to the suggestions given by them. After completing the expert validation, pilot testing was done in small group try-out and large group try-out.

In a small group try-out three teachers were selected to teach a higher secondary class using the metacognitive strategies. Five high achieving students in biology were selected to learn the concepts using the metacognitive strategies developed. Necessary corrections were incorporated as per the feedback given by the teachers and students.

The metacognitive strategies were implemented to a large group try-out having 30 students and 10 teachers. The developed metacognitive strategies were given to science teachers and asked to teach the concept using metacognitive strategies. The same was given to the students to learn the biological concepts with the help of the teachers. The metacognitive strategies were then updated and corrections were carried out according to the suggestions given by teachers. The required updation was made based on the learning experience gained by the students. The pictorial representation of implementation of metacognitive strategies is shown in fig.1.

[Insert fig1 here]

Biology Achievement Test (BAT)

This is a teacher made achievement test constructed by a panel of qualified and experienced teachers. The topics Integumentary System, Skeletal System, Respiratory System, Fungai, Algae and Bryophytes in standard XI text book are chosen as topics to be taught in the study. The draft test consists of multiple choice questions from the selected topic to make the test objective to the fullest extent. Due weightage were given to the content, objectives and difficulty level while preparing the test. The test items were generated based on the blue print followed in school and face validated by 'the two specialists in Biology education. This was done to ensure the content validity of the achievement test. The test items generated were given to the Biology teachers in school to ensure their suitability in terms of appropriateness of language and clarity, and the level of the students. The achievement test was pilot tested among the students of standard XI in the three schools in Tirunelveli District, India. The items are evaluated with the help of difficulty index and discrimination value. Items which are having difficulty index between 40 to 60 and discrimination value 0.4 and above are retained and other items are discarded. The split-half reliability of the test was 0.82. This shows that the tool was found to be reliable.

Metacognitive Awareness Scale (MAS)

In designing metacognitive awareness scale, initially studies of metacognition and standardized instruments for assessing metacognition were reviewed (*Schraw.et.al 1994; Lippmann,2005;, Ibe,2009, Santiago,2010).* Items were prepared after referring the literature related to metacognitive awareness. Experts' opinions were considered to find out the weakness and work ability of the items. The items help to identify the presence of metacognitive behaviour among students. Items were reviewed for face validity. Wording and grammatical structures were changed according to the local Indian context and the target groups' level. The test-retest reliability of the test was 0.78. This shows that the tool was found to be reliable.

Attitude Scale Towards Learning Biology(ASTLB)

This instrument was designed to assess the extent students possess the attitude towards learning biology. It is a five point Likert rating scale which ranges from *strongly agree, agree, undecided, disagree and strongly disagree*. The items of the scale were generated based on review of literature *(Schibeci.1984;Osborne.et.al.2003; Sawtelle.et.al.2009; Kogee.et.al.,2006).* The ASTLB was face validated by subjecting it to peers review. Two educational psychologists reviewed the items to ensure appropriateness and clarity. The ASTLB was pilot tested among the students of standard XI in the three schools in Tirunelveli District, India. They were requested to choose any one of the 5 opinions (*strongly agree, agree, undecided, disagree and strongly disagree)* relating to each item. Responses were scored as 5-1 from "strongly agree" to "strongly disagree" for positive items and 1-5 from "strongly disagree" to "strongly agree" for negative items. Item analysis was done and items with a 't' value of 1.75 and above were selected. The test-retest reliability of the test was 0.82. This shows that the tool was found to be reliable.

Home Environment Inventory (HEI)

The Home Environment Inventory (HEI) is an instrument designed to measure the psycho-social climate of home as perceived by children. The instrument requires pupils to tell the frequency with which a particular parent-child interaction behaviour has been observed by them in their homes.. The HEI was pilot tested among the students

of standard XI in the three schools in Tirunelveli District, India. The students were asked to respond to each item by putting a tick (√) against the entries of a five point scales always, often, sometimes, rarely and never. The weightage assigned are 5, 4, 3, 2 and 1 for the responses *always, often, sometimes, rarely and never* respectively for each item. Item analysis was done and items with a 't' value of 1.75 and above were selected. The content validity of the tool has been established based on expert analysis and judgment. The test-retest reliability of the test was 0.72. This shows that the tool was found to be reliable.

TREATMENT PROCEDURE

Phase I

The tools MAS, ASTLB, HEI and pre-test (BAT) were applied. The responses of the sample to all the tests were scored. The scores obtained by the students were used for further analysis.

Phase II

The study consisted of two different treatments: chalk and talk method of teaching in control group and metacognitive strategy in cooperative learning method in experimental group.

Control group

The control group was taught using chalk and talk method of teaching and the students are answering cognitive questions that were related to the material being taught. Students were asked to share the information with the entire class if they are so desired. The teaching of students in this group was centered on the use of the textbook questions and assignments.

Experimental group

The present study has modified the jigsaw cooperative learning method. The three steps in jigsaw was reduced into two steps according to the suitability of the topic and the subject chosen. In jigsaw, the students are assigned different concepts to learn in the home group. The mastery group was formed by the students from the home group who have learnt the same concept after that regrouping was done. To avoid the confusion in forming the groups thrice, the study has reduced the steps into two for formation of groups. i.e Basic groups and Mastery groups. In this method, the role of teacher is very important to facilitate their learning, after the formation of basic groups. Since the learning among basic group members are taking place with the help of teachers, the learning is directed positively. Jigsaw method was validated using individual try-out and small group try-out and large group try-out.

Step1: Formation of Basic Group in jigsaw cooperative learning

A topic in a subject was broken down into meaningful subtopics called frames. The students in the class are divided into 5 groups with equal number of students. In this study, the sample was divided into 5 groups; each one is called as *basic group* with 7members. Since all the members in the group was identified using numbers, the member in the basic group1 is identified as a1, b1, c1, d1,e1,f1 and g1. The numbering of the members in each basic group is done as follows

Group	**Members**
Basic Group2	a2, b2, c2, d2, e2,f2 and g2.
Basic Group3	a3, b3, c3, d3, e3,f3 and g3.
Basic Group4	a4, b4, c4, d4,e4,f4 and g4
Basic Group5	a5, b5, c5, d5.e5,,f5 and g5

The topic to be learnt by the students was divided into equal number of frame which is equal to the number of basic groups (5 frames). The members in each group was allotted the same frame i.e. the concept to be learnt by all the members in the basic group. Each basic group is allotted different topics. But members in the each group will be learning the same concept. This provides an opportunity to the group members, to discuss about the concept to be learnt. The students will discuss about the topic for around 30 minutes. Likewise all the basic groups will be discussing about their topic. In case of any difficulties faced in learning the concept, the teacher facilitated the learning of the students for better understanding. Once all the group members were learnt the concept, the process of regrouping was done otherwise called *mastery group*. The pictorial representation of formation of basic group is shown in fig.2

[Insert fig2 here]

Step2: Formation of mastery group in jigsaw cooperative learning

The first member (a1) of each frame forms the mastery group1 i.e named as "A". The second member of each

frame forms the mastery group2 i.e. named as "B". Likewise seven mastery groups are formed and it is named as A, B, C, D, E, and G. The pictorial representation of the formation of the mastery group from the basic groups i.e. basic group1 to basic group5 is shown in fig 3.

[Insert fig3 here]

Step3: Learning process

Since the members in the mastery group(A to G) are from the five basic group the member a1 in 'A' explain about the concept learnt in frame1 to the other members in the group and other members were listen to him. Once it was explained, the second member a2 explain about the concept learnt in frame2. To the rest of the members in the mastery group1(A). Likewise the five frames will be learnt at mastery level on discussion with the members in the mastery group. If there is any need of clarification about the topic learnt, the mastery groups are allowed to discuss with the other mastery group members which is shown in fig.4.

[Insert fig4 here]

The teacher collected the metacognitive statements worksheet used by the students after the class on each day to understand the extent of their metacognition. The teacher helped the low achievers to develop their metacognitive ability by means of informal discussions during the class and in free time.

Phase-III Administration of post-test

Soon after the completion of Phase-II, post-test (using BAT) was conducted to two groups on the same day under the supervision of the investigator. The response of the sample to the post test was scored. The scores obtained after evaluation of the answer sheets were subjected to statistical analysis.

Phase-IV Administration of Retention test

After the time interval of 20 days from the conduct of post-test, retention test (using BAT) administered the to experimental group and control group. The responses of the retention test were scored and the scores were subjected to statistical analysis..

ANALYSIS OF DATA

The data was analysed using the descriptive statistics namely Mean, Standard Deviation and for inferential statistics „t" value was calculated to find out the significance difference between the means of control Group and experimental Group. Hypotheses were checked at 0.05 significance level.

MAJOR FINDINGS

The following are the findings were obtained by testing the hypotheses

i. Control group and experimental group students differ significantly in gain scores. When comparing the gain score of experimental group and control group students, experimental group students are better than the control group students.

ii. **a.** Control group, and experimental group students differ significantly in mean gain score of knowledge objective. When comparing the mean gain score of knowledge objective, experimental group are better than the control group students.

b. Control group and experimental group students differ significantly in mean gain score of understanding objective. When comparing the mean gain score of understanding objective, experimental group students are better than the control group students..

c. Control group and experimental group students differ significantly in mean gain score of application objective. When comparing the mean gain score of application objective, experimental group students are better than the control group students.

iii. Control group and experimental group students differ significantly in retention test scores. When comparing the retention test score of experimental group and control group students, experimental group students are better than the control group students.

iv. Home environment and gain score of control group and experimental group are *not correlated* significantly

v. Metacognitive awareness and gain score of control group are *not correlated* significantly. Metacognitive awareness and gain score of experimental group are *correlated* significantly.

vi. Attitude towards learning biology and gain score of control group and experimental group are *not correlated*

significantly.

DISCUSSION

One of the major findings of the present study is that students taught using the metacognitive cooperative learning approach scored higher marks in achievement in biology than those taught using the chalk and talk method. This may have been achieved by the high level of students' participation in learning activities. All the students in the metacognitive cooperative group performed specific roles in learning which are presented in the classroom to the benefit of all members of the group. The results were in agreement with the study result of *Jbeili(2003)* found that metacognitive strategies using cooperative learning was effective in enhancing mathematical performance and mathematical reasoning among fifth grade students in Jorden. *Ibe(2009)* implemented metacognitive instruction through think-pair-share strategy is effective on classroom participation and science achievement. *Santiago(2010)* found that experimental group received metacognition through peer interaction perform better in achievement in chemistry than the control group.

In the present study, the superiority of metacognitive strategies are remarkable in the attainment of achievement objectives namely knowledge, understanding and application. In achievement objective-wise comparisons, experimental group students taught through cooperative learning based metacognitive strategies performed better than control group. In the control group students remained passive listeners in the class while teachers were explaining the concepts of science. Maximum of time was taken by the teacher to talk and no time was given to the students to interact among themselves. Students involvement was found when there were questions raised by the teacher otherwise the students were silently listening to the teacher. Control group students were never given opportunity to interact among themselves.

The results of the study proved that the metacognitive activities helped the students to score better in retention test. The reason is that when conducting the class in metacognitive environment, the concept will be understood better in the student's memory. So they would be able to retain the matter for a much longer period than other students who are taught in the chalk and talk method.

The coefficient of correlation between home environment and gain score was not significant for control group and experimental group. It can be interpreted that gain score had no dependence on home environment. The result of the present study is in agreement with *Gulsum.et.al.(2010),* who found that the parent's educational level, number of reading materials at home, frequency of buying newspapers, presence of a separate study room, and presence of a computer with internet connection at home were not significantly associated with metacognitive strategy use and science achievement. *Laut(2008)* pointed out there is no significant difference in metacognitive abilities between students living in their home environment and also those who have moved away from their home environment and those who have away from their family to persure undergraduate education

Result of the study indicated that metacognitive awareness has significant correlation with gain score of experimental group students. Therefore for every unit change in metacognitive awareness, there is corresponding increase or decrease in gain score. The results of the study are in agreement with the study of *Zakaria et.al(2007)* who found that, there was a significant relationship between metacognitive awareness and students' achievement in mathematical problem solving. *Countinbo(2007)* who found that metacognitive awareness significantly correlated with reading comprehension of text-book.

The coefficient of correlation between attitude towards learning biology and gain score was not significant for control group and experimental group. The result is contradiction with *Santiago.et.al (2010)* revealed that metacognitive environment in cooperative learning can improve science attitude and achievement.

Educational implications

The findings and discussion of the present study have wide implications for the improvement of present system of school education on both theoretical and practical context. It provides guidelines to curriculum development, examination system and teacher education for the possible ways of minimizing the non-utilization of metacognitive strategies.

Curriculum Development

In the light of the present findings, following recommendations are made**.**

i. The cognitive assumptions of the science curriculum materials, particularly at the higher secondary level be re-examined according to students' metacognitive ability.

ii. Model metacognitive strategy packages may be designed and developed by expert teams and made available to the teachers for their classroom.

iii. Textbooks are dominated by declarative knowledge (facts, definitions and descriptions) whereas procedural (knowing how, knowing why) and situational knowledge should be provided for deep study processes. Text book should be designed by raising meaningful and interesting questions and emphasizing applications. Space may be provided adopting metacognitive strategies in having at least for a few topics.

iv. The existing curricula will not be able to cope with the proposed metacognitive strategies. So the curricula must be modified accordingly. To attain achievement objectives more number of research on metacognitive strategies should be conducted and the strategies should be incorporated in the curriculum.

Examination system

The examination or assessment systems and the way these are conducted have a great impact on implementation and the success of a curriculum. Today, the purpose of science education is not give information to students; instead, it is concerned with the development of a wide range of knowledge and understanding, skills and attitudes, process and procedure in science. But, the examination system is so structured that it only judges knowledge of students and their ability to recall memorized facts. No effect is made to assess the metacognitive ability of the students to apply their acquired knowledge in a different situation. In the light of the above proposition it is recommended that

- In order to help students develop metacognitive skills, the examination system should be restructured and the method of assessing students' achievement be reexamined. Questions set in the exam papers should not aim at assessing students' knowledge by recall of facts. Provision must be made to assess higher order thinking skills and intellectual abilities.

Teacher Education

The study has important implications for teacher education. Teacher trainees understand how to structure and monitor meaningful learning experiences for students. The classroom teacher has a critical role in the turning of actual classroom situations into a metacognitive way. Teacher trainees should have an awareness of know-how of metacognitive skills, how it can be instilled and developed among pupils and how the stage can be prepared for teaching-learning process. Therefore practice should be given to develop metacognitive skills for teacher trainees during inter-teaching practice.

Recommendations

Based on the findings of the present study, the following suggestions are made for implementation of the metacognitive strategies.

Teachers

i. Teachers need to bring in paradigm shift from teacher centered methods of teaching to student centered methods, making the students move away from rote memorization to metacognitive way of learning.

ii. Teachers should make effort to reduce teacher dependent learning situations allowing more space to the students to learn by self-planning, self-monitoring, self-evaluation and self-regulation.

iii. Teachers need to create metacognitive environment to the students in the regular class, wherein there is scope of interaction among the students. More emphasis should be laid for processes of science rather than product of science.

iv. While adopting metacognitive strategies in the classrooms, the teachers should give feedback about the practice of metacognitive activities, which will help them to use it appropriately.

v. Teachers should give more opportunities to students practice metacognitive activities. As students practice the activities, provide guidance and support to the students. Give them feedback until they can use the activities independently. As part of your feedback, inform them about where and when the metacognitive activities are most useful.

vi. Group activities proved to be effective and must be encouraged to develop metacognitive skills for all science subjects.

vii. It is found in the study that a positive relationship exists between home environment and attitude towards learning biology. Hence parents must provide special attention to the educational needs of children. The teachers are needed to identify the nature of home environment of each student in their class. The teachers may interact with parents to provide feasible atmosphere for learning at home.

Policy makers

i. From the findings of the study, the higher secondary students learn better by the use of metacognitive strategies. Hence there is a need to change the teaching methods and strategies adopted in higher secondary level.

ii. Special attention is required when a student has significantly greater difficulty in learning than most students of their age. They were not given special care in their studies nor do teachers identify them as low achievers. From the findings of the study, the low achievers would also show considerable improvement if teachers select the metacognitive strategies that would remove their mental deficit.

iii. Chalk and talk method of teaching biology are not compatible with attaining conceptual learning and higher-order cognitive skills. A major purpose of science education should be to develop instructional practices for developing scientific reasoning skills, critical thinking and decision-making capacity. Since metacognition is an inherent component in developing cognitive skills, students and teachers must be taught how to develop metacognition among students. State level academic bodies should develop metacognitive skill enrichment activities.

iv. Appropriate incentives needs to be provided to the creative teachers to motivate them by making their work known to the rest of the teachers to implement it in their schools also.

DELIMITATIONS

This investigation is restricted to Municipal girls higher secondary school, Tirunelveli, India. The investigation is confined to higher secondary students. The topics Integumentary System, Skeletal System, Respiratory System, Fungai, Algae and Bryophytes are alone covered for the experimental purpose. The study conducted for 45 days.

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