CHAPTER-V
SUMMARY, FINDINGS, DISCUSSION & SUGGESTION

5.1 Introduction

The primary objective of science education research and scholarship is to inform teaching and learning practices so as to improve science learning. Given the history of our field and its development since the 1960s it might also be worthwhile to consider how the world has changed since science education began to develop as a distinct field of inquiry. Toffler’s (1970) predictions that the world would witness an explosion in the variety, quantity of, and means of access to information, as well as increased social change, seem to have come to pass to varying extents. The consequent shift in the nature of workforces in Western countries from predominantly labour intensive to more knowledge intensive is also noteworthy. For this Metacognition considered as a key element to students’ development and mental management of their thinking and learning processes. It has been repeatedly argued over the past 30 years that developing and enhancing students’ metacognition is a key to improving their learning of all subjects at school as well as their dispositions and abilities in relation to learning in diverse and emerging contexts in their time beyond formal education.

The issue of teacher metacognition is often not addressed explicitly in the literature. This is not too surprising because the majority of research conducted in relation to metacognition focuses on school students’ thinking and learning processes. However, with an increased emphasis on the development of students’ learning processes it would seem obvious that teachers would need to be in touch with their knowledge, control and awareness of their own thinking and learning processes, especially in relation to cognitive processes related to reform initiatives that call for the development of students’ higher order thinking. This would seem to be a necessary condition for them to serve as cognitive and metacognitive role models for their students. Leou and her co-authors sought to engage teachers in reflection on thinking processes that were the sought after target processes for their school students. While there is an abundance of literature on teacher reflection, a process that is necessary for metacognition, their research explores teachers’ reflections in relation to a metacognitive framework and shows how the use of such a framework may be valuable for teacher professional development.
So keeping in mind the above points researcher conducted study to know the potential of constructivist 5 ‘E’ model in developing metacognitive skills in science student teachers. The summary, findings, discussion and suggestion of this study are given below.

5.2 Rationale

In recent years, metacognition is regarded as an important component of learning in the sciences. The following are a sample of reasons suggested by the literature for this:

(1) In many research studies in the area of science teaching it was found that metacognitive processes promote meaningful learning, or learning with understanding (Thomas & McRobbie, 2001; Davidowitz & Rollnick, 2003).

(2) In view of a constantly changing technological world when, not only is it impossible for individuals to acquire all existing knowledge, but it is also difficult to envisage what knowledge will be essential for the future (Georghiades, 2004). The development of metacognitive abilities that will enable the student to study any desirable knowledge in the future becomes essential.

(3) One of the goals of science education is the development of an independent learner (NRC, 1996; 2005). Efficient independent learning requires the learner to be aware and in control of his/her knowledge and of the options to expand it. This means in other words that the student must utilize and develop metacognitive skills.

Relating metacognition to developing one’s self-knowledge and ability to ‘learn how to learn’ resulted in metacognition being awarded a high status as a feature of learning. The subsequent calling for inclusion of metacognition in the development of school curricula, therefore, seems fully justified. Flavell (1987) proposed that good schools should be ‘hotbeds of metacognitive development’ because of the opportunities they offer for self-conscious learning. Similarly, Paris and Winograd (1990) have argued that students’ learning can be enhanced by becoming aware of their own thinking as they read, write, and solve problems in school, and that teachers should promote this awareness directly by informing their students about effective problem-solving strategies and discussing cognitive and motivational characteristics of thinking. Clearly sharing this view, Gunstone and Northfield (1994) took a step further and argued in favour of a central position of metacognitive instruction within teacher education. Borkowski and Muthukrishna (1992) similarly have argued that
metacognitive theory has considerable potential for aiding teachers in their efforts to construct classroom environments that focus on flexible and creative strategic learning. Voices advocating the importance of metacognitive activity within educational contexts have resulted in placing metacognition high on educational research agendas.

If one is interested in enhancing science teaching and learning, it seems only reasonable to begin with an understanding of how students learn science. Several decades of research in the cognitive and developmental sciences have built a knowledge base that curriculum developers can use. This research has been synthesized by the National Research Council (NRC) and described in several publications, *How People Learn: Brain, Mind, Experience, and School* (Bransford, Brown, & Cocking, 2000), *Knowing What Students Know* (Pellegrino, Chudowsky, & Glaser, 2001), and *How Students Learn: Science in the Classroom* (Donovan & Bransford, 2005). Three principles of learning from this body of knowledge establish the basis for curriculum and instruction. 1. Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts and information, or they may learn them for the purposes of a test but revert to their preconceptions outside the classroom. 2. To develop competence in an area of inquiry, students must (a) have a deep foundation of factual knowledge, (b) understand facts and ideas in the context of a conceptual framework, and (c) organize knowledge in ways that facilitate retrieval and application. 3. A ‘metacognitive’ approach to instruction can help students learn to take control of their own learning by defining learning goals and monitoring their progress in achieving them (Donovan & Bransford, 2005).

Above findings tells us that a ‘metacognitive’ approach to instruction presents an additional element to the design of instructional materials. Michael Martinez (2006) recently elaborated on this aspect of student learning. Going beyond the introductory definition of metacognition as ‘thinking about thinking’, Martinez proposed the definition ‘monitoring and control of thought’ and the specific function of meta-memory and metacomprehension, problem solving, and critical thinking. Martinez suggests three ways of introducing metacognitive strategies in science teaching and curricula. First is an obvious recommendation – students must have experiences that require metacognition. Second, teachers should model metacognitive strategies by ‘thinking aloud’ problem-solving and inquiry based activities. Finally,
students should have opportunities to interact with other students. This suggests the need for group work and an inquiry-oriented approach to the science curriculum which may develop metacognitive skills.

Looking into this conceptual framework researcher came to the conclusion that there are research evidences available which suggest the relation between the metacognition and constructivism. But strong evidences are not available which suggest which among the two work as a cause and other as effect. After studying the constructivist 5 ‘E’ model researcher decided to study the development of metacognitive skills in science student-teachers through constructivist approach using constructivist 5’E’ model. Hence researcher conducted this study to investigate answer of the following questions:

5.3 **Research Questions**

1. Does the constructivist approach in particular 5 ‘E’ model provide opportunities for developing metacognitive skills and in which stages of the 5 ‘E’ model do those skills find expression?
2. What are the metacognitive characteristics that find expression in the various 5 ‘E’ model stages?

5.4 **Statement of the Problem**

The statement of the problem was formulated as below.

Development of Metacognitive Skills in Science Student-Teachers through Constructivist Approach.

5.5 **Objectives of the Study**

The objectives of the study were:

1. To study the development of metacognitive knowledge in science student-teachers while learning science through constructivist (5 ‘E’ model) approach.
2. To study the development of metacognitive regulation in science student-teachers while learning science through constructivist (5 ‘E’ model) approach.

5.6 **Hypotheses**

The following hypotheses were tested to know the development of metacognitive knowledge, metacognitive regulation and metacognitive skills among science student-teachers through constructivist (5 ‘E’ model) approach.

H₀₁ There will be no significant difference between the pre-test score and post-test score of declarative knowledge in science student-teachers.
There will be no significant difference between the pre-test score and post-test score of procedural knowledge in science student-teachers.

There will be no significant difference between the pre-test score and post-test score of conditional knowledge in science student-teachers.

There will be no significant difference between the pre-test score and post-test score of metacognitive knowledge in science student-teachers.

There will be no significant difference between the pre-test score and post-test score of planning skills in science student-teachers.

There will be no significant difference between the pre-test score and post-test score of monitoring skills in science student-teachers.

There will be no significant difference between the pre-test score and post-test score of evaluating skills in science student-teachers.

There will be no significant difference between the pre-test score and post-test score of metacognitive regulation in science student-teachers.

There will be no significant difference between the pre-test score and post-test score of metacognitive skills in science student-teachers.

5.7 Operational Definition of Terms

Following important terms involved in the study were operationalised as below:

5.7.1 Metacognitive skills

Metacognitive skill includes two main component metacognitive knowledge and metacognitive regulation.

1. Knowledge of cognition refers to what individuals know about their own cognition or about cognition in general. It includes declarative, procedural and conditional knowledge (Schraw, 1998) or personnel, task and strategy knowledge Flavell et al. (2002).

   Declarative knowledge includes knowledge about oneself as a learner and about factors that influence one’s performance (knowing ‘about’ things).

   Procedural knowledge refers to knowledge about doing things. Much of this knowledge is represented as heuristics and strategies (knowing ‘how’ to do things).

   Conditional knowledge refers to knowing when and why to use declarative and procedural knowledge (knowing the ‘why’ and ‘when’ aspects of cognition).
Knowledge of person variables—refers to knowledge about how human beings learn and process information, as well as individual knowledge of one’s own learning processes.

Knowledge of task variables—includes knowledge about the nature of particular tasks or more generalized knowledge about types of task as well as the processing demands that will be placed upon the individual.

Knowledge about strategy—variables include knowledge about both cognitive and metacognitive strategies, as well as conditional (contextual knowledge) about when and where it is appropriate to use such strategies.

2. Regulation of cognition refers to a set of activities that help students control their learning. Although a number of regulatory skills have been described in the literature, three essential skills are included in all accounts: planning, monitoring, and evaluation.

Planning involves the selection of appropriate strategies and the allocation of resources that affect performance.

Monitoring refers to one’s on-line awareness of comprehension and task performance.

Evaluating refers to appraising the products and efficiency of one’s learning.

Students possessing these qualities which can be manifested and demonstrated through observation and interview will indicate the possession of metacognitive skills.

Schraw (1998) model was used to analyze data obtained through observation and Flavell et al. (2002) model was used to analyze data obtained through interview and reflective essay.

Apart from these qualitative aspects the score obtained by student-teachers on the metacognitive skill inventory represent metacognitive skills. The each component score was calculated separately which represent that particular skill. The total of the entire components was considered the score of metacognitive skill.

All these behaviours manifested during the learning science through constructivist approach were considered as metacognitive skills.

5.7.2 Constructivist Approach

For the present study constructivist approach means using 5 ‘E’ model that is following the each step of this model engage, explore, explain, elaborate and evaluate. The students are followed through the lesson plan drawn based on 5 ‘E’ model.
5.8 Delimitation of the Study
The study was delimited in terms of following criteria.
1. The study is delimited to the science student-teachers studying in B.Ed. colleges of Gujarati medium.
2. This study includes two models of metacognition given by Schraw (1998) and Flavell et al. (2002) respectively.

5.9 Nature of the Study
The nature of the present study demanded a mixed method approach because it required case study method & exploratory method which come under the qualitative methods and quantitative method of pre-test post-test on single group design.

Since the constructivist approach was used to see whether it can develop metacognitive skills among science student–teachers the review suggested that though both constructivist approach and metacognition are related but the primary evidences were not available which suggest that constructivist approach can surely develop metacognitive skills among students. This means there was scope to explore the potential of constructivist approach (5 ‘E’ model) in developing metacognitive skills. Thus this study demanded for in-depth case study approach to know the potential of constructivist approach (5 ‘E’ model) in developing metacognition. Use of case study would naturally yield qualitative data and so qualitative data analysis strategies were used.

Apart from qualitative method quantitative method was also used to collect the data. Quantitative data was obtained to see whether there is significant development in metacognitive skills after the programme from before the programme. For this pre-test and post-test was conducted on single group. Thus mixed method of qualitative and quantitative approach was used to get comprehensive study of the development of metacognitive skills using constructivist approach.

5.10 Population
The population of the study was all students studying in Bachelor of Education (B.Ed.) course having science as their one of the method in B.Ed. colleges affiliated with Hemchandracharya North Gujarat University, Patan of 2009-10 academic year.
5.11 Sample of the Study

The sample for the present study was selected purposively for the present study. The study was conducted on the Bachelor of Education (B.Ed.) students having science background. All ten students selected were Master of Science degree holder coming from rural and urban area of Palanpur tehsil of Banaskantha district.

The present study was conducted in Shree Banaskantha Kadva Patidar Sanskar Mandal Sanchalit College of Education, Palanpur which was affiliated with the Hemchandracharya North Gujarat University, Patan. The college was selected purposively.

5.12 Tools

The following tools were used for the present study.

1. Observation
2. Interview
3. Reflection Essay
4. Metacognitive skill Inventory

5.12.1 Observations of the Classroom Activity

During the study, 30 observations were conducted during the classroom learning activities. Two groups were audio-recorded and transcribed. During the classroom activity student-teachers were asked and motivated to think aloud while learning. Whatever student were thinking and discussing with each other were audio recorded.

5.12.2 Students’ Interviews

During the study, ten student-teachers who studied through constructivist 5 ‘E’ model were interviewed before the program and after the program. For this unstructured interview were conducted which include around twenty questions regarding their learning styles and awareness they had regarding their metacognitive ability.

5.12.3 Students’ Reflective Essays

Student-teachers who had taught through constructivist 5 ‘E’ model were asked to write a reflective essay after each learning session. Altogether 300 reflective essays were collected from ten student-teachers.

5.12.4 Metacognitive Skills Inventory

Apart from the above mentioned qualitative tools researcher had tried to know the level of metacognition quantitatively also. For this purpose the metacognitive skill
inventory were prepared by the researcher. Two components of metacognitive skill metacognitive knowledge and metacognitive regulation were selected. Metacognitive knowledge has three subcomponent declarative knowledge, procedural knowledge and conditional knowledge while metacognitive regulation has planning, monitoring and evaluation subcomponent. Reseacher collected 200 items from the different sources from that 115 items were selected for the piloting. After piloting 4 items were removed and remaining 111 items were selected, which were arranged randomly according to the component of metacognition.

Prepared MSI was having test-retest reliability 0.86, split-half reliability 0.84 and KR21 reliability 0.80. Apart from it the MSI had face validity, content validity and concurrent validity.

5.13 Educational Programme

For the development of metacognitive skills in science student-teachers, constructivist lesson plan based on the 5 ‘E’ model was prepared by the researcher. First of all researcher had selected science content which support the constructivist approach for developing metacognitive skill. Then the objectives for preparing this programme were decided. Based on this the programme based on constructivist 5 ‘E’ model were prepared. Prepared programme was pre-piloted and experts’ opinion were taken and based on this necessary changes were made. After this piloting of the programme was done and based on this final form of the programme was prepared.

5.14 Data Collection

Data was collected through implementing the programme and through implementing the MSI.

5.14.1 Implementation of Programme

Constructivist 5 ‘E’ model lesson plan was implemented on the 10 B.Ed. student-teachers from science background. For this first of all permission was taken from the Principal of Shree B.K.K.P.S.M. College of Education. Since this programme was of thirty hours, permission for 10 weeks time duration was taken from the Principal. The programme was implemented for three days a week. For this the student were introduced with the research objectives. They were briefed about the programme, duration of the programme, about audio recording and interview to be conducted. The oral informed consent was taken from them and those students willing to participate during this programme were selected for the implementation of the
programme. First of all the two groups of five was formed. The group-1 comprised of Tarun, Jagdish, Dinesh, Paresh & Aashish while group-2 comprised of Rachana, Dabhi, Harsha, Sailesh & Sanjay. The constructivist 5 ‘E’ learning programme was implemented on the both groups. The whole learning programme was audio-recorded. After each learning session one student was interviewed and all ten student-teachers were writing their reflective essays and thus data related to observation through audio-recording, interview through audio-recording and reflective essays were obtained.

5.14.2 Implementation of MSI

MSI was implemented twice on the student-teachers, first before implementing a programme. During this student-teachers were briefed about how to give response in the inventory, what information they should provide. The student-teachers were asked to give freely. Enough time was provided to student-teachers to give their response on each item. They were told not to leave any statement. Thus the filled inventories were then collected from the student-teachers.

After completion of the programme again the MSI was implemented. The same MSI was given to the student-teachers and again they had to give response on each statement. The filled inventories were collected from the student-teachers.

5.15 Scoring of the inventory

The collected inventories were then scored. First, one student’s inventory was taken and if student has selected always option then 5, for frequently 4, for sometimes 3, for occasionally 2 and for never option 1 score was allotted to each statement. Then each statement score was summed up to get individuals score on the inventory. Thus each students score on the MSI was obtained.

5.16 Data Analysis

The data collected was analyzed qualitatively as well as quantitatively. For qualitative data analysis the obtained data through audio-recording of classroom activity, student reflection essay and interview of students were translated. Then coding of the qualitative data was done. The data obtained through these tools were triangulated to get complete picture of metacognitive knowledge and metacognitive regulation development. They were then logically presented to know the potential of constructivist 5 ‘E’ model in developing metacognitive skills.
Data obtained through audio-recording, interview and reflective essays were analyzed using appropriate technique. The data obtained through audio-recording, interview and reflective essays were triangulated to increase the validity of data. To properly arrange the data and accurate analysis of data coding framework was developed. Different coding framework was developed for different data obtained through different tools to analyze the data. Schraw (1998) model of metacognition was used to develop coding framework for the analysis of data obtained through audio-recording. Flavell et al. (2002) model of metacognition was used to develop coding framework for the analysis of data obtained through interview. But no systematic coding framework could be developed for reflective essays because of the varied nature of reflections. However, these reflections were content analyzed and used to strengthen the arguments presented.

Quantitative data was analyzed through non-parametric technique. The Wilcoxon Sign Rank Test was used to test the significance of differences between pre-test and post-test score. For each component Wilcoxon Sign Rank Test was utilized. If the Z-value obtained is significant then the constructivist approach (5 ‘E’ model) was considered to be effective in developing metacognitive skills.

**5.17 Hypotheses testing**

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<th>No.</th>
<th>Hypotheses</th>
<th>Z-value</th>
<th>Significance</th>
<th>Rejected/Not rejected</th>
</tr>
</thead>
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<td>H₀₁</td>
<td>There will be no significant difference between the pre-test score and post-test score of declarative knowledge in science student-teachers.</td>
<td>8.21</td>
<td>0.01</td>
<td>Rejected</td>
</tr>
<tr>
<td>H₀₂</td>
<td>There will be no significant difference between the pre-test score and post-test score of procedural knowledge in science student-teachers.</td>
<td>8.21</td>
<td>0.01</td>
<td>Rejected</td>
</tr>
<tr>
<td>H₀₃</td>
<td>There will be no significant difference between the pre-test score and post-test score of conditional knowledge in science student-teachers.</td>
<td>8.21</td>
<td>0.01</td>
<td>Rejected</td>
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Table 5.1 contd…

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<th>$H_{04}$</th>
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<td>$H_{05}$</td>
<td>There will be no significant difference between the pre-test score and post-test score of planning skills in science student-teachers.</td>
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<td>$H_{06}$</td>
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<td>$H_{07}$</td>
<td>There will be no significant difference between the pre-test score and post-test score of evaluating skills in science student-teachers.</td>
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<td>0.01</td>
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<tr>
<td>$H_{08}$</td>
<td>There will be no significant difference between the pre-test score and post-test score of metacognitive regulation in science student-teachers.</td>
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<td>$H_{09}$</td>
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<td>8.21</td>
<td>0.01</td>
<td>Rejected</td>
</tr>
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5.18 Major Findings

Major findings of the study were:

1. Engage phase provided the opportunity to express Metacognitive Knowledge (MK) and Metacognitive Regulation (MR) behaviours.
2. During engage phase more Metacognitive Knowledge (MK) behaviours were observed compared to Metacognitive Regulation (MR) behaviours.
3. During engage phase among Metacognitive Knowledge (MK) behaviours Knowledge about what he knows and doesn’t know (DKH) behaviours was expressed maximum number of times. Other behaviours expressed in decreasing number of their appearance were Knowledge about others knowledge (DKO), Knowledge of how to do things (PK), and Knowledge about when to do things (CKW).
4. During engage phase among Metacognitive Regulation (MR) behaviours Online awareness of his comprehension (MHC) behaviours were expressed maximum number of times. Other behaviours expressed in decreasing number of their appearance were Select appropriate strategy of reframing the question (PAS), Online awareness of task performance (MTP), Appraise his learning (EAL) and Evaluate their gained knowledge (EGK).

5. Explore phase provided the opportunity to express Metacognitive Knowledge (MK) and Metacognitive Regulation (MR) behaviours.

6. During explore phase more Metacognitive Regulation (MR) behaviours were observed compared to Metacognitive Knowledge (MK) behaviours.

7. During explore phase among Metacognitive Knowledge (MK) behaviours Knowledge about what he knows and doesn’t know (DKH) behaviours were expressed maximum number of times. Other behaviours expressed in decreasing number of their appearance were Knowledge of how to do things (PK), Knowledge about when to use DK & PK (CKDP), Knowledge about others knowledge (DKO) and Knowledge about when to do things (CKW).

8. During explore phase among Metacognitive Regulation (MR) behaviours Online awareness of his comprehension (MHC) behaviours were expressed maximum number of times. Other behaviours expressed in decreasing number of their appearance were Select appropriate strategy of reframing the question (PAS), Appraise his learning (EAL), Makes judgement about his learning (EJL), Online awareness of task performance (MTP), Examines other students learning (EOL) & Allocation of resources (PAR).

9. Explain phase provided the opportunity to express Metacognitive Knowledge (MK) and Metacognitive Regulation (MR) behaviours.

10. During explain phase more Metacognitive Regulation (MR) behaviours were observed compared to Metacognitive Knowledge (MK) behaviours.

11. During explain phase among MK behaviours Knowledge about what he knows and doesn’t know (DKH) behaviours were expressed maximum number of times. Other behaviours expressed were Knowledge of how to do things (PK).

12. During explain phase among Metacognitive Regulation (MR) behaviours Online awareness of his comprehension (MHC) & Appraise his learning (EAL) behaviours were expressed maximum number of times. Other behaviours expressed in decreasing number of their appearance were Select
appropriate strategy of reframing the question (PAS) and Makes judgement about his learning (EJL).

13. Elaborate phase provided the opportunity to express Metacognitive Knowledge (MK) and Metacognitive Regulation (MR) behaviours.

14. During elaborate phase Metacognitive Knowledge (MK) & Metacognitive Regulation (MR) behaviours were observed in same numbers.

15. During elaborate phase among Metacognitive Knowledge (MK) behaviours Knowledge about what he knows and doesn’t know (DKH) behaviours was expressed maximum number of times. Other behaviours expressed in decreasing number of their appearance were Knowledge about when to use DK & PK (CKDP), Knowledge about others knowledge (DKO), Knowledge of how to do things (PK) and Knowledge about when to do things (CKW).

16. During elaborate phase among Metacognitive Regulation (MR) behaviours Online awareness of his comprehension (MHC) behaviours were expressed maximum number of times. Other behaviours expressed in decreasing number of their appearance were Select appropriate strategy of reframing the question (PAS), Online awareness of task performance (MTP), Appraise his learning (EAL) and Makes judgement about his learning (EJL).

17. Evaluate phase provided the opportunity to express only Metacognitive Regulation (MR) behaviours.

18. During evaluate phase Metacognitive Knowledge (MK) behaviours were not observed.

19. During evaluate phase among Metacognitive Regulation (MR) behaviours Makes judgement about his learning (EJL) & Appraise his learning (EAL) behaviours were expressed maximum number of times.

20. There was significant development of Declarative Knowledge in science student-teachers through constructivist approach.

21. There was significant development of Procedural Knowledge in science student-teachers through constructivist approach.

22. There was significant development of Conditional Knowledge in science student-teachers through constructivist approach.

23. There was significant development of Metacognitive Knowledge in science student-teachers through constructivist approach.
24. There was significant development of Planning skill in science student-teachers through constructivist approach.

25. There was significant development of Monitoring skill in science student-teachers through constructivist approach.

26. There was significant development of Evaluating skill in science student-teachers through constructivist approach.

27. There was significant development of Metacognitive regulation in science student-teachers through constructivist approach.

28. There was significant development of Metacognitive skill in science student-teachers through constructivist approach.

From the above findings it could be concluded that constructivist approach (5 ‘E’ model) definitely provides greater opportunity for the development of metacognitive skills and different characteristics of metacognitive skills find expression during each stage of 5 ‘E’ model.

5.19 Discussion of Findings and Conclusion

With respect to the findings of this research an attempt has been made to compare these results with the results of the other study in this area. Case & Gunstone (2006) through their study on “metacognitive development: A view beyond cognition”, suggested that metacognitive development needs to be characterized in broader terms than the usual cognitive focus in order to more fully account for student experiences of learning. In the present study researcher also did not emphasize the metacognitive development only, in terms of cognitive focus, rather took full account of students experiences of learning through constructivist approach in which they themselves construct the meaning of experiences they get. Thus it can be ascertained that a broader framework is required to fully comprehend metacognitive development among the students.

While the study of Kung & Linder (2007) on metacognitive activity among students in the physics laboratory found that greater amount of metacognition does not appear student’s success in the laboratory. However in the present study, it was observed that student teachers were doing well in laboratories, showing more metacognitive behaviours than the other activities. Such contradictory findings indicate replication of studies to arrive at conclusive findings. Although it is commonly believed that laboratory experiences do provide more opportunity for
students to develop their metacognitive skills, we still need to think as to how this can be actualized.

The study of Davidovitz & Rollnick (2003) on enabling metacognition in the laboratory found that all students were engaged in metacognitive practices during the laboratory work. Same results were obtained from the present study. Here researcher observed that student-teachers engagement in learning through constructivist model in their respective groups in a co-operative and collaborative way expressed metacognitive behaviours both in classroom as well as in laboratories. But both these studies results contradict with the results of Kung & Linder (2007) studies. Such contradictive findings indicate for further replication of these kinds of studies to arrive at conclusive findings. Also there is a need to study the factors which lead to contradictory findings so that these factors can be avoided to arrive at one conclusive result which can be generalized like laboratory experiences provide opportunity for metacognitive development.

In the study of Kipnis & Hofstein (2008) on inquiry laboratory as a source for development of metacognitive skills found that while performing the inquiry activities, student practiced their metacognitive abilities in various stages of the inquiry process. In the present study researcher found that during each stage of constructivist 5 ‘E’ model student-teachers were expressing their metacognitive skills in terms of MK and MR. Each stage provide opportunity to practice metacognition and thus constructivist approach has a potential to develop metacognitive skills in students. Thus result of both these study are quite similar. This indicate that there is a need for exploration of connection between inquiry process and 5 ‘E’ model stages in terms of metacognitive development. Also there is a need to conduct comparative effectiveness between inquiry stages and 5 ‘E’ model stages in developing metacognitive skills.

Through his study on growth of metacognitive awareness in kindergarten children through the writing process Jacobs (2004) found that children showing growth in their metacognition during writing process. In the present study researcher observed that student showing their metacognitive behaviours while discussing some concepts, principles problems or experiments in science with each other. Thus constructivist 5 ‘E’ model provide opportunity to discuss with each other which help to develop metacognitive skills. This indicates that there is need to explore which way the metacognition can be developed better through writing process or through
discussion process. Is there any opportunity to use both processes in combination so that metacognition can be developed more compared to individual process. Apart from it Jacobs (2004) got results on kindergarten students while present study result is on adult learners. Thus there is need to look whether through writing process metacognition can be developed in adult and metacognition can be developed in children through discussion process. Also there is need to explore at each stage of development of individual which process work best and at what degree, writing or discussion or combination of both in developing metacognitive skills.

Through their study on uncovering students’ thinking about thinking using concept maps, Richtart, Turner & Hardar (2009) found that concept map instrument proved to be a robust instrument for uncovering students thinking about thinking. In the same line constructivist 5 ‘E’ model also prove to be powerful model for uncovering students thinking about thinking. These results suggest that there is need to study comparative effectiveness of concept maps and constructivist 5 ‘E’ model in uncovering students’ thinking about thinking. Richtart, Turner & Hardar (2009) also found that students’ conceptions of thinking do improve with age but also can be substantially developed through a classroom culture where thinking is modeled and rich opportunities for thinking are present. In the present study researcher also found that metacognition develop when rich opportunities for thinking are present. Thus result of both study were supportive to each other. But there is need to compare which means provides more opportunities for thinking, concept maps or constructivist 5 ‘E’ model. Also there is need to compare the strength and weaknesses of both instrument in developing metacognitive skills.

In the study of Leutwyler (2009) on metacognitive learning strategies: differential development patterns in high school, he found that there is no development of student self-reported use of metacognitive learning strategies during high school. The findings of this study differ from the present study in which researcher found development of student-teachers self-reported use of metacognitive learning strategies during constructivist learning. Thus there is need to conduct study about factors responsible for development of students self-reported use of metacognitive learning strategies and factors responsible for hindrance in development of metacognitive learning strategies. Apart from it whether age of students is responsible for this disparity needs to be explored.
The study of Bannert & Mengelkamp (2008) on the assessment of metacognitive skills by means of instruction to think aloud and reflect when prompted found that prompting students for metacognitive reflection affect learning performance positively. Whereas, in present study researcher found that during constructivist learning they get opportunity to practice metacognitive reflection which in turn develops metacognitive skills among science student-teachers. Although the objective of the present study was not to study the effect of metacognitive reflection on learning performance, during interview with student-teachers they admitted that constructivist learning helps in improving learning performance. Thus the results of both studies support each other.

In the study of McKeown & Gentilucci (2007) on Think-Aloud Strategy: metacognitive development and monitoring comprehension in the middle school second language classroom, they found that English learners successfully use metacognitive strategies such as think-aloud. In the present study researcher also found that student-teachers successfully use think-aloud strategies while learning science through constructivist approach. Thus it can be observed that think-aloud strategy is a powerful metacognitive strategy useful in developing metacognitive skills. But this need to be further explored in different learning environment and at different levels of learners.

In the study of Thomas, Anderson & Nashon (2008) on the development of an instrument designed to investigate elements of science students’ metacognition, self-efficacy and learning processes: The SEMLI-S they found that SEMLI-S can be used for either analyzing or focusing on any or all of its dimension or for assigning scores to individuals that enable comparison between them in relation to their metacognitive science learning orientation. In the present study researcher observed that MSI could be used to measure students on their metacognitive skills while learning science through constructivist approach. Here there is a need to compare both the tools on capacity of measuring metacognitive skills. Though both the tools measuring metacognition the MSI measure metacognition in constructivist environment while SEMLI-S measure metacognition in science learning environment. Thus applicability of both tools differs.

Through their study on development of two observational tools for assessing metacognition and self-regulated learning in young children Whitebread & et al. (2009) found that development of (CHILD 3-5) checklist is potentially highly
beneficial. In the present study researcher also found that MSI is useful in assessing the metacognitive skills. The (CHILD 3-5) is useful to assess metacognition of children of 3-5 ages while MSI is useful for adult learner. Though there is scope to explore component used in both tools which is very much useful to assess the metacognition.

In the study of Burrows (2003) on results of a controlled experiment that tested the effectiveness of Lord’s teaching model he found that teaching in a constructivist active learning environment is more effective than traditional instruction in promoting academic achievement, increasing concept understanding and developing higher level thinking skills. In the present study researcher also found that constructivist learning environment is effective in developing higher order thinking skills like metacognitive skills. Thus findings of both studies complement each other. But still there is need to explore which higher order skills develop through Lord’s model and through constructivist model academic achievement could be improved or not.

From the above discussion it can be concluded that metacognitive developments needs to be looked beyond the cognition taking full account of students learning. Although laboratory experiences provides more opportunities for developing metacognitive skills compared to classroom learning, there is scope for replication of study because of variations in results. There is also scope for researchers to compare the development of metacognition through discussion and writing process at different levels of learner i.e. children, adolescent and adults. Researcher found that metacognition develops when opportunities for thinking is provided. So there are ample scope for research to find different techniques, methods and approaches which provide better opportunity for thinking which results into metacognitive development. Apart from it the correlation between metacognition and learning performance of students need to be checked. Although think-aloud strategy works best to assess the metacognition of students, other strategy needs to be studied, which helps in assessing metacognition. Though researcher prepared the MSI to measure the metacognition of students in constructivist environment other tools need to be prepared which can measure the metacognition of different level students in different environment.

In the end, it can be concluded that constructivist learning environment definitely provides greater opportunity for the development of metacognition but replication of studies involving different levels of learners in different subjects will
yield conclusive results, which will be boon for curriculum framers and policy makers.

5.20 Educational implications

5.20.1 For students

➤ Constructivist way of learning should be encouraged in them.
➤ Instead of only memorizing, how to learn skill should be inculcated in students.
➤ Instead of memorizing the learning, construction of learning skill should be encouraged in them.
➤ Students should be encouraged to develop their metacognitive skills.
➤ Science learning should be based on the constructivist approach so that students could develop concepts and principles of science as well as could develop metacognitive skills.

5.20.2 For Teachers

➤ Teacher should be encouraged to teach in a constructivist way.
➤ Teacher should create constructivist classroom environment so that metacognitive skills could be develop in students.
➤ Teacher should not give direct answer of the questions rather ask students to search for the answers.
➤ Teacher should model metacognitive skills so that students could imitate it.
➤ Teacher should arrange such activities which encourage constructivist way of learning in students.
➤ Co-operative and collaborative learning should be encouraged in them.
➤ Instead of direct instruction learning how to learn skill should be encouraged in students.

5.20.3 For Principals

➤ Principals should create school environment giving importance to metacognitive skill development rather then marks.
➤ They should ask teachers to teach some chapters of the subject using constructivist approach.
➤ They should encourage teachers to prepare lesson plans based on constructivist approach.
➤ They should arrange workshops for training his teachers about how to practice constructivist approach.
They should see that learning outcome is evaluated in terms of metacognitive development along with cognitive development.

They should made effort to change the mindset of parents for giving importance to metacognitive development rather than only marks.

5.20.4 For Parents

- Parents should give importance to constructivist way of learning instead of just memorizing the learning.
- They should encourage their children to develop metacognitive skills instead of developing memory skills.
- They should emphasize metacognitive learning instead of traditional learning.

5.20.5 For curriculum developers

- Curriculum developers should include content of the subject which is based on constructivist approach.
- They should put such activities in the exercise which is based on constructivist approach so that students can perform that activity and in turn develop metacognitive skills.
- They should mention the minimum level of metacognitive skill which could be developed at each grade in textbook itself.
- Content should be according to the development of metacognitive skill at each stage of cognitive development of the students.
- They should arrange training programmes for teachers about using different models of constructivist approach to teach the different subject.
- Training programmes for teachers to develop metacognitive skill among student should also be arranged.

5.20.6 For Teacher Training Colleges

- Teacher training colleges should teach constructivist approach as a part of the Methods.
- Student-teachers should be trained to use constructivist approach as a part of practice teaching.
- They should conduct different researches to best practice the constructivist approach in real classroom.
- Different evaluation technique should be developed to measure metacognitive skill development in students.
They should search for other approaches and methods to develop metacognitive skills.

Student-teachers and Teacher-educators should develop instructional design based on constructivist approach.

Teacher-Educators should use metacognitive instruction to model how to develop metacognition in student-teachers.

Teacher-Educators should use constructivist approach as a pedagogical tool for their classroom transaction so that student-teachers could imitate them.

5.21 Recommendation for further research

Researcher made following suggestion for further research in this area

1. Other models of constructivist approach should be used to develop Metacognitive skills.

2. This approach should be used to develop Metacognitive skills of students of pre-primary, primary, secondary, higher secondary or college level.

3. Same study could be conducted for subjects other than science.

4. Other approaches apart from constructivist approach should be used to develop metacognitive skills.

5. Longitudinal study of metacognitive skill development should be conducted.

5.22 Conclusion

From the present study it could be concluded that constructivist approach (5 ‘E’ model) definitely provides greater opportunity for the development of metacognitive skills and different characteristics of metacognitive skills find expression during each stage of 5 ‘E’ model. It also proves the researchers’ assumption that the constructivism and metacognition are related with each other and constructivist environment is conducive for the metacognitive development. But replication of studies involving different levels of learners in different subjects will yield conclusive results, which will be boon for curriculum framers and policy makers.