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Development of Metacognitive Skills in Science Student-Teachers Through Constructivist Approach

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Abstract

Metacognition and Constructivism is a related to each other because as we construct our knowledge at the same time we also develop awareness of construction of knowledge. Thus they are two side of the same coin. Researcher decided to study whether constructivist approach in particular 5 'E' model provide opportunities to develop metacognitive skills in the science student-teachers studying in B.Ed. colleges of Hemchandracharya North Gujarat University, Patan. For studying this objective researcher used Mixed-Method design of Convergent Parallel design. Researcher used Case Study method and exploratory method of qualitative approach and pre-test post-test single group design of quantitative approach. 10 science student-teachers were taught through 5 'E' model and their classroom activity were audio recorded. After each lesson one of the student were interviewed and all student were writing the reflection essay. These three kind of data were then triangulated. Metacognitive skills Inventory were administered before and after the programme. The quantitative data were analyzed through Wilcoxon Sign-Rank Test. The programme was of 10 weeks. The analysis of data suggest 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.

Keywords: Metacognitive skill, constructivist approach, development, constructivist 5 'E' model

Metacognition, a term introduced in the 1970s by Flavell (1971, 1979, 1987), is often defined as one's knowledge, awareness and control of the domain of cognition (Brown, Bransford, Ferrara, & Campione, 1983), or as thinking about one's own thinking. It entails conscious reflection on what one knows about a given task, and demonstrating ability to describe what s/he is currently doing, talk about his/her feelings about the learning situation in which s/he is engaged, and use this information to monitor and enhance one's performance (Georghiades, 2006).

Metacognition was originally referred to as the knowledge about and regulation of ones cognitive activities in learning processes (Flavell, 1979; Brown, 1978). Under the umbrella of this inclusive definition a proliferation of metacognitive terms has unfolded through the years (Veenman, Van Hout-Wolters & Afflerbach, 2006).

Schraw & Moshman (1995) version of metacognition help us to further elaborate this concept which says "metacognition includes two main subcomponents generally referred to as knowledge of cognition and regulation of cognition." Metacognitive knowledge is categorized in two ways. One way of categorization was given by Flavell (1979) and other way of categorization was given by Schraw & Moshman (1995). Both Model are discussed in operational definition. Based on this metacognitive skill can be defined as "it includes knowledge of cognition and regulation of cognition. When student use declarative, procedural and conditional knowledge and planning, monitoring and evaluating skills they are said to be engaged in using metacognitive skills." Apart from it the *metacognitive skill* component refers to the control of an individual's ongoing cognitive processes. Flavell (1979) argued that learners must learn to use their MK and self-directive capabilities to steer their cognition and feelings during learning performance. With reference to development of metacognition Theory-of-Mind develops somewhere between the age of 3 to 5 years (Flavell, 2004; Lock & Schneider, 2006). In the years thereafter, metamemory and metacognitive knowledge develop, but continue to do so during life span (Alexander, Carr & Schwanenflugel, 1995). Metacognitive skills emerge at the age of 8 to 10 years, and expand during the years thereafter (Veenman & Spaans, 2005; Veenman *et al.*, 2004). Moreover, certain metacognitive skills, such as monitoring and evaluation, appear to mature later on than others (e.g., planning).

Much research concerning science teaching and learning is responsible for major shifts in science teacher education. Cognitive science has become a research focus around the world since the early 1980s (Georghiades, 2004). Basically, this research reveals that most people learn the kind of science that is useful in places other than the classroom and laboratory, where students are merely expected to repeat what they are told, follow directions, and remember information and results on recall type examinations. Another research field focuses on the Constructivist Learning Model (Bybee et al, 1989; von Glaserfeld, 1987; Yager, 1991). The research seems conclusive; most people learn only when they construct meaning for themselves. Such research must provide the basis for future science teacher education programmes. Without the research base provided by cognitive science and constructivist studies, improved models for science teacher education cannot be developed.

Learning is a social as well as individual process, and individual's learning does not occur in a vacuum. Such a position is consistent with a social constructivist orientation. Advocates of such an orientation for example, Milne & Taylor (1995), have suggested that (a) learning involves personal mental construction of knowledge by individuals, (b) learner subscribe to their conceptual structures, not because they are absolute, but because they are viable for them as individuals, and (c) knowledge construction is a social and cultural process mediated by language. The development of metacognitive strategies is seen as a crucial element in developing constructivist- oriented classrooms (Gunstone, 1994; Paris & Winograd, 1990). Further Baird, Freshman, Gunstone & White (1991) have argued that "constructivism complements metacognition in effecting personal change" and "adequate metacognition empowers the learner to undertake the constructivist processes of recognition, evaluation and revision of personal views." Metacognitive strategies are integral and necessary functionaries in constructivist classrooms where their ability to interpret and transform information in a given social setting and monitor their progress while doing so are essential.

Thomas (1999, 2002) has argued that students' metacognition is socially mediated and that the nature of the classroom learning environment is an important factor influencing the development of students' metacognition. Keeping this in mind, researcher had decided to study the development of metacognitive skills through constructivist approach.

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). 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. 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.

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. 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).

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 given by Bybee, researcher decided to study the development of metacognitive skills in science student-teachers through constructivist approach using constuctivist 5'E' model. Hence researcher conducted this study to investigate answer of the following questions:

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?

Statement of the Problem

The statement of the problem was formulated as below.

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

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.

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.

H_{01} There will be no significant difference between the pre-test score and post-test score of declarative knowledge in science student-teachers.

H_{02} There will be no significant difference between the pre-test score and post-test score of procedural knowledge in science student-teachers.

H_{03} There will be no significant difference between the pre-test score and post-test score of conditional knowledge in science student-teachers.

H_{04} There will be no significant difference between the pre-test score and post-test score of metacognitive knowledge in science student-teachers.

H_{05} There will be no significant difference between the pre-test score and post-test score of planning skills in science student-teachers.

H_{06} There will be no significant difference between the pre-test score and post-test score of monitoring skills in science student-teachers.

H_{07} There will be no significant difference between the pre-test score and post-test score of evaluating skills in science student-teachers.

H_{08} There will be no significant difference between the pre-test score and post-test score of metacognitive regulation in science student-teachers.

H_{09} There will be no significant difference between the pre-test score and post-test score of metacognitive skills in science student-teachers.

Operational Definition of Terms

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

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.

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.

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.

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 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 convergent parallel design was used to get comprehensive study of the development of metacognitive skills using constructivist approach.

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.

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.

Tools

Audio-Recording 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.

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 semi-structured interview were conducted which include around twenty questions regarding their learning styles and awareness they had regarding their learning.

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.

Metacognitive Skills Inventory

Metacognitive skill inventory was 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. Researcher 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.

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 constructivist 5 'E' model programme 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.

Data Collection

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

Implementation of Programme

Constructivist 5 'E' model lesson plan was implemented on the 10 B.Ed. student-teachers from science background. The programme was implemented for three days a week. 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 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.

Administration of MSI

MSI was administered twice on the student-teachers, first before implementing a programme. 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 scoring scheme used was, for always option 5, for frequently 4, for sometimes 3, for occasionally 2 and for never option 1 score was allotted to each statement.

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. 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. These all three form of data were then logically presented in the form of case-study to know the potential of constructivist 5 'E' model in developing metacognitive skills. 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.

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.

Discussion of Findings and Conclusion

From the comparison of results of the study with previous research 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.

Educational implications

- 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.
- Teacher should create constructivist classroom environment so that metacognitive skills could be develop in students.
- Principals should create school environment giving importance to metacognitive skill development rather then marks.
- 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.
- Curriculum developers 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.

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

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.

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