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A Study of the Impact of Constructivist Approach on Students' Understanding the Concepts of Work, Energy and Power at Senior Secondary Level

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Abstract: ***Teaching learning the concepts of work, energy and power can be made joyful, interesting and fruitful activity by adopting constructivist approach in which students are expected to be engaged in acquiring methods and processes that take care of learners' curiosity and creativity particularly in relation to the learning environment. Teachers are expected to provide environment in which students interact meaningfully with academic materials/resources facilitating the teaching learning processes related with the concepts of work, energy and power. Present research study has been carried on students of two group's viz. experimental group and controlled group to investigate the impact of constructivist approach on their understanding the concepts of work, energy and power at senior secondary level. Analysis of the students' responses clearly revealed a significant difference between students' understanding of experimental and controlled groups about the concepts of work, energy and power.***

Keywords: constructivist approach, concepts of work, energy & power, learning environment and teaching-learning process

1. Introduction

During past three decades constructivist approach of learning has got immense focus in the physics education [1-28]. This approach is student centered approach in which the input is obtained from sensory organs and output is formed as the cognitive structures [1-7]. In this approach, students construct their own knowledge of the world through experiencing things and reflecting on those experiences [7]. In this paradigm, learning emphasizes the process and not the product [8-12]. Learning is not viewed as transfer of knowledge but students actively construct their knowledge on the basis of knowledge already held. The role of teacher is to create environment in which students interact meaningfully with academic materials/resources fostering the learning processes of selecting, organizing and integrating information and act as a facilitator not as knowledge dispenser [7-16]. Teaching learning the concepts of physics such as work, energy and power can be made joyful, interesting and fruitful activity by adopting constructivist approach. Constructivist approach engages the students in acquiring methods and processes that nurture their curiosity and creativity particularly in relation to the environment. Teaching - learning the concepts of physics is characterized by focused emphasis on processes viz. minute and careful observations, sensing of problems, literature survey/consulting teachers or and peer group members/friends, identification of a particular problem, experimentation for seeking solution, data collection, analysis and interpretation of data, drawing inferences, testing and modifying the hypotheses and scope for further studies [7-13]. Present study is related with the students' understanding the concepts of work, energy and power at senior secondary level. Concepts of work, energy and power are very fundamental in basic physics. Its effects are distinctly perceptible in every branch of physics, mechanics, electromagnetism, nuclear physics or any other branch of science. Work, energy and power have a basic role in almost every scientific phenomenon. One begins experiencing work, energy and power from an early age in life. A student of science begins formal learning about work, energy and power from elementary level yet conceptual clarity eludes many for a quite long time [8-21]. In the present research study investigations have been carried out on students of two groups viz. experimental group and controlled group to examine the impact of constructivist approach on students' understanding the concepts of work, energy and power at senior secondary level. It was hypothesized while conducting the study that there is no significant difference between the understanding of students of experimental group and controlled group regarding the concepts of work, energy and power. Keeping above in view, efforts were made to create constructivist teaching learning environment. This was done by adopting following steps during teaching-learning the concepts of work, energy and power:

- To discover what students already know about the concepts of work, energy and power.
- To compare what they think about with what they are actually observing regarding the concepts of work, energy and power.
- To connect their previous experiences with the conceptual frame work of the concepts of work, energy and power.
- To ensure students' involvement, encouragement in the teaching learning process and giving them opportunity through group exercise, group work, quiz, project work, presentation of concepts through concept mapping and expression of thoughts and sharing of their views on the concepts of work, energy and power during the teaching –learning process.
- To apply the concepts of work, energy and power in new/unfamiliar situations and relate them with previous experiences.
- To assess students' conceptual understanding about the concepts of work, energy and power.

- To know the socio-economic background of the students through questioning.

2. Sample and Methodology

Author of the present paper has got an opportunity to conduct fieldwork of three months in Government Senior Secondary School (Rural School), Phulera, Jaipur, Rajasthan (India). Therefore, sample for the study was taken in form of the two groups of students of Government Senior Secondary School (Hindi Medium), Jobner Road, Phulera Jaipur, Rajasthan (India). One group of students was the one in which regular teaching learning was done using *constructivist approach which was* designated as *experimental group* and the other group was in which *traditional approach (Chalk and talk (lecture))* of regular teaching learning was adopted. This group of students was designated as *controlled group*. A total number of 46 students were in each group. Inorder to investigate conceptual understanding of these students a research tool (questionnaire) comprised of multiple choice questions related to the concepts of work, energy and power was administered on the sample groups of students. There were 20 questions in the questionnaire. Questionnaire was prepared in Hindi medium as the school was Hindi medium. Open ended questions were also included in the questionnaire. One question was related with concept mapping on the concepts of work, energy and power. Tool was administered on both the groups of students simultaneously. Value of 't' was calculated for students of both the groups using *Data Entry: Student's 't' -Test* [2] and compared with the tabulated value [23] to see the significant difference between the understanding of the concepts of students of experimental and controlled groups. Before beginning the regular classroom teaching learning process, students were asked the following questions [26]:

- What are educational qualifications of your mother and father?
- What is occupation of your parent and how much is monthly income of your parent?
- How many brother/sister do you have?
- In which school do they study?
- What is your future prospectus? Would you like to become a Teacher/Sports person/ Social worker/Doctor/Engineer/ Leader/ Other? Please give answer with logic.
- Who is your role model?
- Do you watch news on TV regularly?
- Do you study with NCERT textbooks? Give your feedback?
- Which subject do you like the most and Why?
- Which chapter of Physics textbook you like the most and why?
- Do you like to do your homework/revision of chapters of your physics textbook every day?
- Do you come to school regularly?
- What curriculum would you like to study? Please write your suggestions in details.
- Do you face any difficulty in expressing yourself in the class room?
- Which approach of teaching learning you like most and why?

The common concern was that the family environment of the students does not encourage them for learning. Students were having fear of their teachers. However, their teachers were good enough to promote them toward their study. It was noticed from the classroom observations and interactions that students were very hesitant in asking questions to their teachers in the regular classroom situation. It was also noticed that the teaching learning process was unresponsive and passive in the regular classroom teaching learning process being carried out using traditional approach. Keeping above factors in view, efforts were made to make students' friendly learning environment. Accordingly a motivational and icebreaking activity session was organized for the students to build up learning environment. Students were suggested to behave like friends and ask questions during teaching learning process. Their involvement and participation in different activities related with the teaching learning process was ensured through group exercise, group work, quiz, seminar, project work and oral presentation of concepts related with work, energy and power. They were also encouraged to participate in preparation and presentation of concept maps on work, energy and power. Freedom for expression of students' thoughts and interactions during the teaching –learning process of the concepts of work, energy and power was given and appreciated. Attention was focused on the following important aspects of constructivist approach [1-13]:

- Asking open ended questions and seeking students' responses and reflections.
- Encouraging students for higher level thanking.
- Engagement of students in dialogue with peers and facilitator.
- Engagement of students in experiments/activities that motivate them for discussion.
- Inquiring students about their understanding the concepts of work, energy and power.
- Students were facilitated to analysis and interpret the given data related with concepts of work, energy and power and draw the inferences.

After considering the above aspects, teaching learning process of the concepts of work, energy and power for students of class XI of experimental group was commenced using constructivist approach (Fig.1) [1-13].

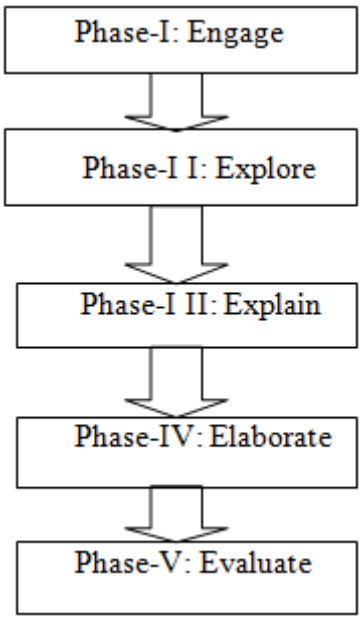


Figure 1: Phases of constructivist approach

Students were also motivated to reflect, predict, infer, discuss and design activities related to the topic during teaching learning process. Keeping above in view, teaching learning process was carried out on the following topics:

- Work done by a force.
- Work done by a variable force.
- Work energy principle.
- Conservative and non-conservative force.
- Principle of conservation of energy.
- Collisions.
- Problems related with work, energy and power.

Students were facilitated in learning the answers of the following questions related with the topic "work, energy and power" during regular teaching learning process:

- How work, energy and power are associated with each other?
- Suggest few practical examples related with work, energy and power?
- Can you perform work without energy? Comment it.
- If you are riding a bicycle while coming from home to school, what type of work you are performing and what type of energy needed for riding a bicycle?
- Why is no energy being consumed in planetary motion?
- When you are talking to your friend using a mobile for an urgent work, do you think you are performing a work and consuming energy?
- When you class teacher is writing on blackboard, does he/she perform work?
- How work is related with energy?
- What are the applications of energy in our day to day life?
- Suggest few activities related to work, energy and power.
- Cite few examples of domestic applications of energy.
- What are other the applications of energy and how many types of energy are known to you?
- Give remarks on the topic work, energy and power. How these three terms are linked together?

Students were asked to form small groups in the class to discuss the topics related with work, energy and power and summarize their discussion in the following tables:

Table 1(a) for Group 1	
Sr. No.	Work done by a force
1	
2	
3	
4	
5	
Table 1(b) for Group 2	
Sr. No.	Work energy principle
1	
2	
3	
4	
5	
Table 1(c) for Group 3	
Sr. No.	Conservative and non-conservative force
1	
2	
3	
4	
5	
Table 1(d) for Group 4	
Sr. No.	Principle of conservation of energy & collisions
1	
2	
3	
4	
5	

After consolidation of the group work, students of each group presented their group works done on the respective topics. Students were motivated to interact and raise their questions during the presentations. Students were also motivated to relate/link their experiences gained outside the classroom situation to their presentations (classroom situation). They were encouraged for sensing of problems, literature survey/consulting teachers or and peer group members, identification of a particular problem, experimentation for seeking solution, data collection, interpretation of data, drawing inferences to any one topic of their choices related with the concepts of work, energy and power. Some photographs of the activities conducted during teaching-learning process are given below:

1 (a)

1 (b)

1 (c)

1(d)

Photograph 1 (a, b, c & d) shows students' participation in the group work on work, energy & power.

2 (a)

2 (b)

2 (c)

2(d)

Photograph 2 (a, b, c & d) shows students' participation in the presentation of their group works on work, energy & power.

3(a)

3(b)

3(c)

Photograph 3(a, b, d & c) shows students' participation in the quiz competition

Photograph 4 shows students' participation in written assignments/group exercise

Photograph 5 shows students' participation in the presentation of the project works

6(a)

6(b)

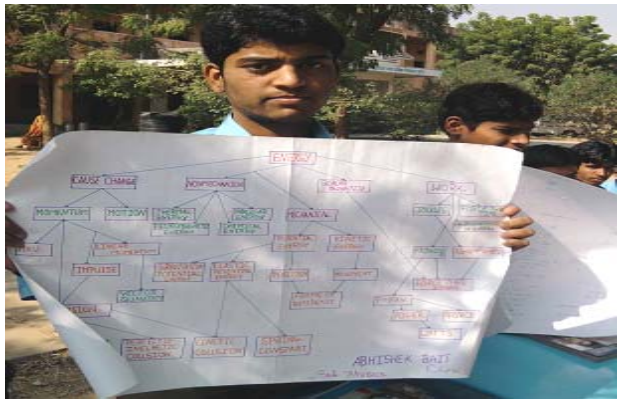
Photograph 6(a & b) shows students' observation of the exhibition of the projects

7(a)

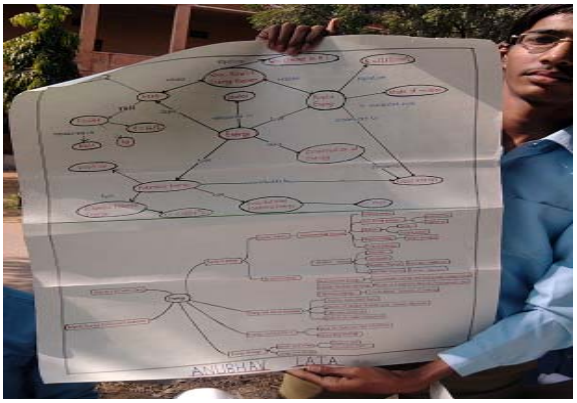
7(b)

7(c)

Photograph 7(a, b & c) shows students' participation in the activity of concept mapping on work, energy & power.

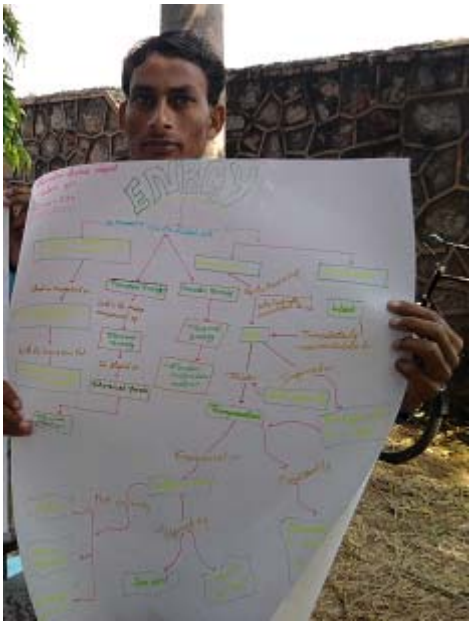


8(a)



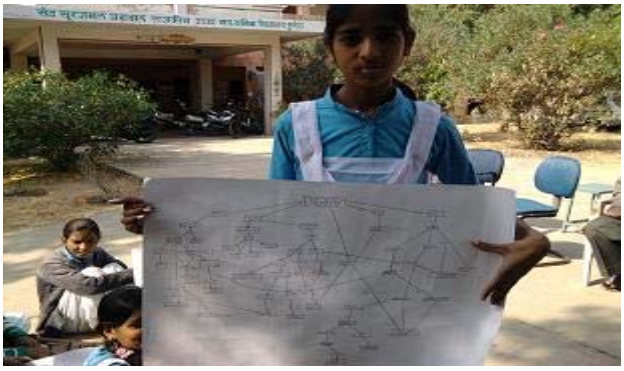
8(b)

8(c)



8(d)

8(e)



8(f)

8(g)

Photograph 8(a-g) shows students' participation in presentation of their concept maps on work, energy & power

Lesson on the topic work, energy and power was concluded by interaction with the students and giving them home assignment to prepare concept maps on the concepts studied in the classroom transaction. Assessment of students' learning during conduct of the activities (group exercise, group work, presentation of concepts through mapping, oral presentation of concepts, experimentation/conducting practical's and expression of thoughts) related with the teaching –learning process of concepts of work, energy and power was done continuously and comprehensively through observation, orally asking open ended/higher level thinking/skills based questions, administering questionnaire and engaging them in discussion (Photographs 1-8). They were also asked to summarize the lesson after its completion in the class using graphical tools. Students were personally interviewed and feedback regarding them was also taken from their teachers. They were encouraged to solve the problems on black board and present their ideas about a particular concept of work, energy and power (Photograph1). Their work was regularly examined and corrective measures were taken accordingly. They were also given opportunity to reflect and imbibe on various aspects of the activities performed by them. There was regular practice in the classroom to ask questions in between and after the completion the topic/concept. Students of the classes were grouped into small group. Each member of the group was assigned a topic for seminar, group work presentation, written assignments, projects and practicals. Proper record of each activity was maintained. During the presentation of assignments, students of the class were allowed for cross questioning or to ask any other relevant questions without any hitch and fear to their peers. It resulted in charging up the students to question things in the classroom and to apply their natural curiosity to the world outside the classroom situations [24-28].

3. Analysis of the Data and Results

- Analysis of the responses of students of controlled & experimental groups in terms of percentage of correct, wrong and un-responded responses were carried out to each item of the questionnaire related with the concepts of work, energy and power and their percentages of the responses are listed in Table 2 and shown graphically in Figure 2 and 3 respectively. Average percentage of correct responses, wrong responses and un-responded responses of students of experimental group was 67.10, 31.70 and 1.20 respectively where as for students of controlled group respective average percentage was 34.20, 54.70 and 11.10 for correct responses, wrong responses and un-responded responses.
- Only 2.7% students of controlled group responded item No. 20 of the questionnaire which was related with the preparation of concept map on work, energy and power where as 94.7% students of experimental group (where constructivist approach of teaching learning was used) responded this item correctly. Similar situation prevails in item No. 19 in which applications of work, energy, power and momentum was explored in daily life situations.
- Mean scores, standard deviation (S.D.) and 't' value of students of controlled and experimental groups were calculated and compared with the tabulated values (Table 3) which reveals that there is a significant difference in the conceptual understanding the concepts of work, energy and power of two groups of students. Performance of students of experimental group is batter in comparison to students of controlled group where traditional teaching learning approach was employed. This is clearly evident from Table 2 and graphical representation of responses (Figures. 2-4) of students of both the groups. Scores shown in the box plot of data for both the groups (experimental group (A) & controlled group (B)) (Figure 4 & Table 3) depict similar situation.

- At significant level 0.05 calculated 't' value (6.41) from the data scores of students is higher than the tabulated 't' value (2.02) [23] which indicates that there exists a significant difference in the understanding the concepts two groups of students. Therefore the null hypothesis is not accepted.

Table 2: Analysis of the responses of the students of controlled & experimental groups

Item No.	*Concept*	*Controlled Group*			*Experimental Group*		
		% of Correct Responses	*% of Wrong Responses*	*% of Un-responded Responses*	*% of Correct Responses*	*% of Wrong Responses*	*% of Un-responded Responses*
1	Force & work	47.2	52.8	0	55.2	44.8	0
2	Conservative force	19.4	77.8	2.8	47.3	52.7	0
3	Variable force &work	41.7	58.3	0	78.9	21.1	0
4	Force & work	0	100	0	60.5	39.5	0
5	Energy	25	66.7	8.3	78.9	21.1	0
6	Force constant	5.6	88.8	5.6	78.9	21.1	0
7	Energy	66.7	27.7	5.6	73.6	26.4	0
8	Force & work	16.7	44.4	38.9	57.8	39.5	2.7
9	Force & work	25	75	0	60.5	39.6	0
10	Conservative force & potential energy	33.3	66.7	0	60.5	34.2	5.3
11	Rate of change of momentum	58.3	38.9	2.8	73.6	26.4	0
12	Inelastic collision	63.9	36.1	0	52.6	47.4	0
13	Power	38.9	58.3	2.8	60.5	39.5	0
14	Constant power	30.6	69.4	0	55.2	39.5	5.3
15	Force & work	75	25	0	73.6	21.1	5.3
16	Head on collision	55.6	41.6	2.8	73.6	26.4	0
17	Potential energy	41.7	58.3	0	60.5	39.5	0
18	Mechanical energy	8.3	75	16.7	60.5	39.5	0
19	Work, energy, power & momentum	27.8	27.8	44.4	84.2	15.8	0
20	Work, energy & Power	2.7	5.6	91.7	94.7	0	5.3

Table 3: Mean scores, standard deviation (S.D.) and't' value of the students of controlled & experimental groups

Group	N	Mean	Median	S.D.	't' *value
Experimental	46	25.5	23	4.67	6.41
Controlled	46	12.5	11.5	7.97	

*Significant at 0.05 level and degree of freedom =38

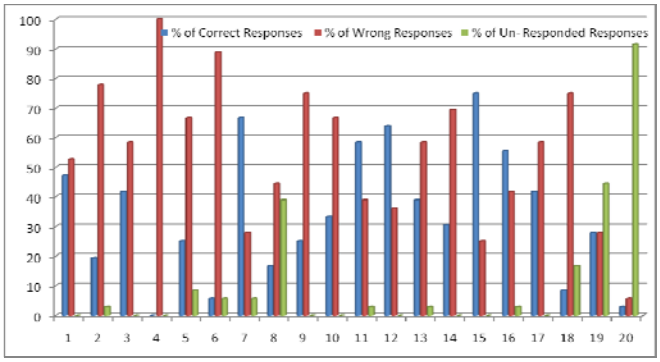


Figure 2: Graphical representation of students' responses of controlled group (percentage (%) of responses is given on y-axis and item number is given on x-axis).

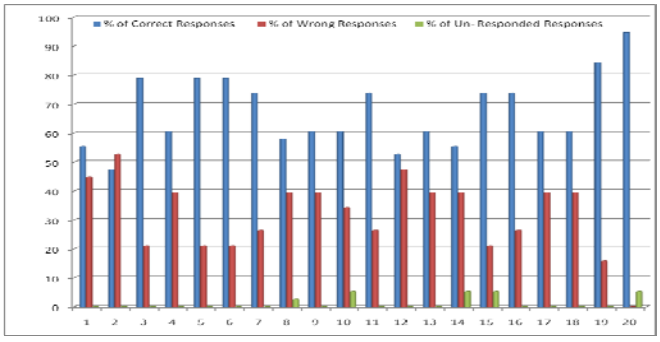


Figure 3: Graphical representation of students' responses of experimental group (percentage (%) of responses is given on y-axis and item number is given on x-axis).

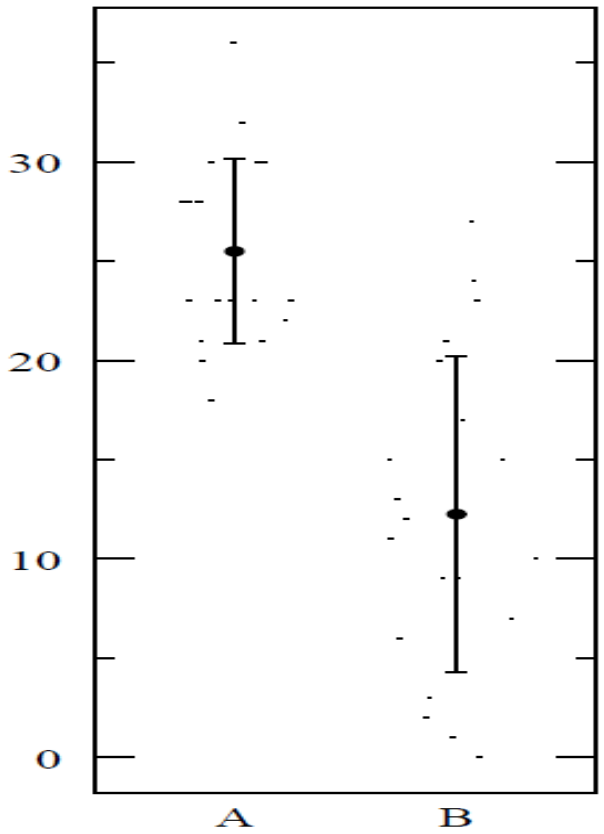


Figure 4: Box Plot of data of students of experimental group (A) and controlled group (B)

4. Implications

- During the field work common concern experienced was that the family environment of the students does not encourage them for learning. Lack of motivation of students was also noticed. Students were having fear of their teachers. However, their teachers were good enough to promote them toward their learning the concepts of work, energy and power. It was observed that students were very hesitant in asking questions during the teaching learning process in the classroom situation. It was also observed that the teaching learning process was unresponsive and passive in the regular classroom teaching learning process where traditional approach of teaching learning was employed. It was experienced that there exists rigidity amongst teachers in accepting the educational challenges with regards to today's scenario in relation with curriculum, class room situation, teaching learning materials/resources, use of ICT in teaching learning process, teaching learning approaches, quality of education and examination reform. It is, therefore, envisaged that efforts have to be made to make students friendly constructivist learning environment in the schools. Students should be encouraged to behave like friends and ask questions during teaching learning process. Their involvement and participation in different activities related with the teaching learning process must be ensured through group exercise, group work, quiz, seminar, project work and oral presentation of concepts related with work, energy and power. They should also be motivated for participation in presentation of concepts of work, energy and power through concept mapping and experimentation/conducting practicals. Students should be motivated to use of graphical tools for their presentations on concepts of work, energy and power.
- During teaching learning process it was found that students were not fluent in their communications during the interaction. Accordingly adjustment may be made by the teachers to match with their frequency of communications and learning the concepts of work, energy and power.
- It was noticed during the interaction with teachers that that most of the teachers of the school have not attended any training/workshop/refresher course/orientation programme related with curriculum review, ICT based class room, development of teaching learning materials/resources, constructivist approach in teaching learning process and examination reforms. It is suggested that teachers should be exposed periodically to such programmes where they can refresh and update their content and pedagogic aspects and appraised about the emerging trends of the educational challenges of today's scenario.
- None of the teachers was engaged in research activities leading to effective teaching learning process, quality of education and professional development of students and teachers. Participation of teachers in aforesaid research activities/programmes should be ensured at school level.
- Traditional approach (Chalk and talk (lecture)) of teaching learning was the only near and dear approach to the teachers at school level; they like it the best and employ it the most in their class room situations. It should be realized that mastery of content and approach of delivery of content both are equally important during the teaching learning process at school level. Also keeping in view the better performance of the students of experimental group over the students of controlled group it is suggested that there should be a shift from traditional approach to constructivist approach of learning the concepts of work, energy and power.
- Performance of students is independent of their background (rural/urban). Opportunity, motivation, constant efforts, reinforcement and remedial measures may result in enhancing their performance and understanding the concepts of work, energy and power notably.

5. Conclusion

It can be concluded that the students' performance significantly improved while teaching learning process was carried out using constructivist approach. Constructivist approach places more emphasis on sensory input as compared to traditional approach of teaching learning where students were found to sit passively through lectures and take notes. In constructivism approach students were actively involved, rather than passively absorbing information and the teacher acted as a facilitator. Students were found to get an opportunity to concentrate on learning how to think and understand the concepts of work, energy and power as constructivist teaching learning approach is based on students' explorations, hands on activities and sharing of their experiences.

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