Experiential Learning Interventions for In-Service Teachers and Teacher Educators in Science at Secondary Level

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Abstract

In a capacity building programme for the State Resource Groups (SRGs) of 25 teachers or teacher educators from Jammu & Kashmir and Ladakh, experiential learning interventions were given to SRGs to handle experiential learning process in Science at Secondary level by selecting chemical reactions as an exemplar concept. The programme was conducted at the Regional Institute of Education (RIE), National Council of Educational Research and Training (NCERT), Ajmer. During the programme, Kolb's experiential learning cycle was exercised to give hands-on experience and capacity building of SRGs in the area of chemical reactions in classroom situations by following various stages of experiential learning. As per the interaction and feedback received from the SRGs, the present form of experiential learning intervention has been successful in the capacity building of SRGs to handle the experiential learning process in classroom.

Introduction

Experiential learning is referred to as learning through direct experience or learning by doing and in general, learning through reflection on doing (Agarkar and Brock, 2017). Kolb's experiential learning theory is represented by four main concepts; experiencing, reflecting, thinking

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and acting upon an experience, and these concepts from the namely stages of learning cycle of concrete experience, reflective observation, abstract conceptualisation and active experimentation (Kolb, 1984).

The learning cycle can begin at any one of these stages but a learner must go through all the four stages to complete the learning cycle. Various research studies have indicated that experiential learning is a successful learning (Voukelatou, 2019; Kong, 2021) it is a strong instrument for bringing about positive modifications in the academic performance of the learners (Zhai et. al., 2017; Bradberry, and De, 2019). Considering the importance of experiential learning, the National Education Policy 2020 has also recommended that in all stages, experiential learning will be adopted (NEP, 2020). The teacher's primary role in experiential learning is to create suitable learning experiences and facilitate the learning process. It is very well established that teacher should be competent enough to handle the experiential learning process, and thus, interventions are required for capacity building of teachers to run the experiential process with desired competence (Azuelo al., 2015; Hafeez, 2021). NCERT plays central role in developing competent teachers through intervention or capacity building programmes for the teachers and teacher educators. The present study is a part of the 'Capacity Building Programme for SRGs in Experiential Learning Strategies in Science at Secondary Level' conducted at RIE, NCERT, Ajmer. During the present programme one of the sessions was designed for capacity building of the participants in experiential learning by considering chemical reactions as an exemplar concept; the findings of the study are presented in the paper.

Review of Literature

The Experiential Learning Theory developed by Kolb and Fry (1975) proposed that learning takes place in a four step cycle, i.e., concrete experience, reflective observation, abstract conceptualisation and active experimentation. In Science education, experiential learning is considered as an effective pedagogical approach which is able to foster deeper understanding and engagement among students. A teacher plays the central role in experiential learning, and thus, teachers should be competent enough to run the experiential learning process effectively. Various studies have indicated that professional development programmes for teachers integrating experiential learning plays a significant role in enhancing their pedagogical practices. A brief survey of the literature indicating effectiveness of different aspects of experiential learning is given below.

Tuss (1996) pointed out that Science learning activities based on the experiential model are better able to promote construction of scientific knowledge and provoke students

into making the transition from basic to higher-order, scientific ways of thinking.

Uyen et. al., (2022), studied the effectiveness of experiential learning in Mathematics with respect to students' participation, motivation and interest in learning. The impact of experiential learning on the students was also studied. It has been discovered through observation and analysis of experimental teaching, and assessment results that teaching through experiential activities is highly effective and feasible.

In the research study conducted by Antonio Lealg and Gema (2019), it has been concluded that fostering experiential learning strategies favours the students' understanding of theoretical concepts, and leads to the attainment of superior performance.

According to Gorghiu and Santi (2016), experiential learning has significant role in student's motivation, knowledge transfer, creativity and self-confidence which influence development of metacognitive skills, practical and independent work skills, exploratory skills and efficient learning through non-formal activities. The study has also indicated the students' perception related to their involvement in a series of non-formal activities.

The research study conducted by NG et. al. (2019) showed that the experiential learning approach demonstrates the crucial role of facilitating constructive learning for undergraduate students from various disciplines to develop innovative pedagogical and learning skills.

Ajani (2023) indicated the significant role of experiential learning in teachers' professional development for enhancing classroom practices. It has been emphasised that experiential learning theory can be adopted into teachers' professional development, as an effective approach to engaging teachers in classroom-enhanced activities. The study encourages integrating experiential learning initiatives in the teachers' professional development programmes to improve teachers' classroom pedagogies and teaching competencies for quality education.

Brendan et.al. (2016) conducted research on the use of experiential learning during the early stages of teacher professional development and explored the impact of implementation of experiential learning approach on teachers to make significant pedagogic changes as part of a major curriculum reform.

As per the study conducted by Marlow and McLain (2011) the professional development of formal Science educators through extraordinary experiences makes them extraordinary and valuable.

In summary, the reviewed literature highlights the significance of experiential learning in the learning process. Thus, there is need to integrate experiential learning in professional development programmes for teachers. The present study has an impact of the review of the literature presented above.

Educational Implications of the Study

Experiential learning has gained considerable attention in the area of Science education. Research studies have proven that the experiential learning activities in teaching learning process of Science are successful in enhancing student outcomes. Teaching efficacy and the present study has been conducted considering the importance of experiential learning interventions in teaching efficacy. It has been observed that the present mode of intervention significantly contributes in improving teaching efficacy. Thus, if the present mode of interventions is adopted in different areas of school education, it will have a positive impact in improving teaching efficacy and student outcomes.

Need and Significance of the Study

National Education Policy 2020 (NEP 2020) has recommended that in all stages, experiential learning will be adopted and accordingly, NCERT has developed National Curriculum Frameworks for School Education 2023 in which experiential learning is emphasised in all the curricular areas. A teachers primary role in experiential learning is to create suitable learning experiences and facilitate the learning process hence it is required that teacher is a competent enough to handle the experiential learning process. NCERT plays a central role in developing competent teachers through research, training, development and extension activities as per educational needs of the nation. Considering the importance of experiential learning as per recommendations of NEP 2020 the present programme was approved by Programme Advisory Committee (PAC) NCERT. Accordingly, programme was conducted at RIE, NCERT, Ajmer and the present study is a part of the said programme. A general discussion with the SRGs revealed that theystill exercise traditional methods of teaching and there is a need of capacity building in handling the experiential learning process. Thus, present interventions were planned for capacity building of the participants in handling the experiential learning process in the five-days programme; present session is conducted particularly on experiential learning of chemical reactions.

The SRGs of the programme will act as resource person in the similar programmes conducted by the respective UTs. And this will significantly contribute in capacity building of teachers in handling the experiential learning process in science.

Objectives of the Study

The main objectives of the present study were:

- To enrich the SRGs on various aspects of experiential learning.
- To give interventions for capacity building of SRGs to handle experiential learning process in Science.

- To study the capacity building of SRGs with respect to experiential learning.

Sample

The sample of the study consisted of 25 teacher and teacher educators (participants) working in DIETs, and Secondary schools of Union Territories (UTs) of Jammu & Kashmir and Ladakh identified using cluster random sampling strategies. The participants and trained teachers were qualified with some having B.Ed. degree, and some having even higher degrees like Ph. D. in their respective subject area. These participants were deputed as SRGs by the respective UT authorities to participate in the PAC, NCERT approved programme entitled 'Capacity Building of SRGs in Experiential Learning Strategies in Science at Secondary Level' held at RIE, NCERT, Ajmer.

Sharing of Previous Experiences

To make the experiential learning process more effective and need-based, an interaction was made and a questionnaire was also administered to know whether the participants are able to run the experiential learning based process in the Science classroom. It was observed that experiential learning process or not has not been exercised in Science class by most of the participants. It was very clearly shared by the participants that they are not competent enough to handle the experiential learning process. It was also shared that they want to use this method, but it is a time-consuming process and completion of the prescribed syllabus is time-bound. It was also mentioned that the experiential learning-based process will involve participation of students in activities which will disturb classroom management. Considering the observation, experiential learning interventions were planned to address the issues shared in the previous experiences.

Methodology

As discussed above, a general interaction with the participating SRGs was made using some open ended and closed questions like:

- What pedagogical aspects are recommended in the NEP 2020?
- Are you aware about experiential learning?
- What is Kolb's experiential learning cycle and what is its significance?
- Have you undergone any training programme on experiential learning?
- Are experiential learning resources available in your institute?
- Have you exercised experiential learning process in science teaching?
- In your opinion which method of teaching is more appropriate in teaching Science?

- What are the challenges if experiential learning process is used in teaching Science, etc.?

It was observed that SRGs have knowledge about pedagogical aspects recommended in the NEP 2020 and experiential learning. However, no one attended any training programme on experiential learning. Experiential learning resources in Science are available to a limited extent. However, experiential learning process in Science teaching is still not exercised by them. It was shared that they are not competent enough to handle the experiential learning process. Some of them mentioned that it is a time consuming process and thus, it is not exercised. Some questions were also asked related to content of Science especially on chemical reactions, and it was observed that participants have a good content knowledge.

On the basis of above discussion interventions for capacity building in handling the experiential learning process in the classroom situation were planned and in a systematic manner a session was initiated by considering Kolb's learning cycle as discussed below.

Stages of The Experiential Learning Cycle

After brief discussion on various aspects of experiential learning, Kolb's experiential learning cycle was discussed in detail for proper understanding of the theory. It was explained that according to Kolb, there are four stages of learning as under:

Concrete Experience (CE)

At this stage, learners gain experience through special occasions, examples and exposure to new tasks. In these situations, knowledge is acquired by the learner by observing, hearing about or reading about someone else's experiences. In general, this phase emphasises on doing the activity.

Reflective Observation (RO)

At this stage learner develops various perspectives by thinking on what is learnt and observed. This stage also allows the learner to ask questions and discuss the experience with others.

Abstract Conceptualisation (AC)

In this stage of learning cycle, the learner draws conclusions from the experience and creates theories to explain the observation. In simpler words, at this stage focus of learner is on drawing conclusions and learning lessons based on the experience.

Active Experimentation (AE)

At the stage of active experimentation, learners have to apply their new ideas to the world around them to see if there are any changes in the next occurrence of the experience. In general, this stage allows students to learn through implementations of their learning.

Fig. 1: Discussion on experiential learning

It was also explained that in view of the above learning cycle, teacher should facilitate the teaching learning process in science in the following way:

- Concrete Experience—facilitates students to do the activity.
- ReflectiveObservation—facilitates reflection on performance in the activity.
- Abstract Conceptualisation—facilitates applying theory to the experience of doing the activity.
- Active Experimentation facilitate in considering theory and reflection for subsequent experiences.

It is not necessary to begin from concreate experience, but for proper learning all the four elements in the cycle should be performed.

Considering the learning cycle discussed above, the process of interventions was initiated to develop competence in SRGs to handle the experiential learning cycle by considering chemical reaction as an exemplar concept. Experiential learning is learner-centric so participants of the programme were divided into groups of five participants each. To initiate the activities of learning cycle, each group was facilitated to enter in the experiential learning cycle at the stage of concrete experience followed by other stages of the cycle. The details of activities corresponding to each stage of cycle is given below in the form of results and discussion.

Result and Discussion

Experiential Learning of Chemical Reaction

Considering the stages of the experiential learning cycle, each group was facilitated to perform the learning activities based on the concept of chemical reaction at Secondary level which is as follows:

1. Concrete Experience

For concrete experience of chemical reactions each group was facilitated to do the following activities and record

their observations. The different steps of activity were as under:

Activity Part I

(i) Take the cleaned Magnesium piece in the test tube.

(ii) Add some water and boil it.

(iii) Add blue and red litmus papers to it.

Activity Part II

(i) Now take magnesium ribbon and burn it with the help of pair of tongs.

(ii) Collect the end product in a watch glass and add some water.

(iii) Add blue and red litmus papers to it.

2. Reflective Observation

Now each group was facilitated to share their observation, experience, and reflect upon it within their group and also with other groups. It was shared that in the first part of the activity, there is no change in the colour of the litmus papers. However, in the second part, the red litmus paper turned blue.

3. Abstract Conceptualisation

Considering the observations and reflection, it was asked whether the end products in the activities are same or different. Further, it was asked whether the product formed on burning of magnesium can again be converted into magnesium. At this stage, participants were able to conceptualise that the end products of the above activities are different because there is no change in the colour of litmus papers in the first part of the activity but in the second part, the red litmus paper turned blue. Further, it was also conceptualised that product formed in the second part of the activity cannot be again converted into magnesium because there is formation of a new product on burning of magnesium ribbon.

Considering the reflections mentioned above participants were facilitated to conceptualise that in a chemical reaction, a new substance is formed and energy is either released or absorbed, and in general chemical changes or reactions are irreversible. So the burning of magnesium ribbon is an example of a chemical reaction. In the above reaction, burning requires oxygen so in this case magnesium oxide (collected in watch glass) is formed and being basic in nature it turns red litmus into blue. It is different from magnesium because the colour of the litmus paper did not change, when simply, water having magnesium pieces was boiled.

4. Active Experimentation

As discussed above, this stage allows learners to learn through implementations of their learning so participants were again facilitated to perform a new activity and record their observations as under:

- Take about 1g copper powder in a china dish and heat it.

It was shared that copper powder turned black on heating due to formation of copper oxide; it is also a chemical reaction because the copper oxide formed on heating of copper powder is different from the unheated copper powder and the process is irreversible.

As a facilitator, it was further discussed that in the above process we got concrete experience by performing an activity. Observations were recorded while performing the experiment and learner reflected upon it. Based on the reflections, we have conceptualised that there is chemical reaction in burning of magnesium. In performing the activity of heating of copper powder, we are simply implementing our learning for subsequent experiences and it is the stage of active experimentation in the learning cycle.

As per interaction with the SRGs all the steps of learning cycle were clear to them and they were also encouraged to apply the cycle in learning of various types of chemical reaction in Science at secondary level. Therefore, the interventions through experiential learning of different types of chemical reactions were given as discussed below.

Experiential Learning of Different Types of Chemical Reactions

Considering the approach of experiential learning discussed above, a process was initiated for experiential learning of different types of chemical reactions as given below:

Experiential Learning of Decomposition Reactions

For experiential learning of decomposition reaction, participants were facilitated to complete the learning cycle as given below:

1. Concrete Experience

Participants were facilitated to perform the following activities and record their observations.

Fig. 2: Experiential learning of chemical reactions

- Take some $Pb(NO_3)_2$ in a boiling tube.
- Heat the boiling tube over a flame with the help of a pair of tongs.

2. Reflective Observations

At this stage of learning, participants were facilitated to share their observations. It was shared that on heating of $Pb(NO_3)_2$, there was emission of brown fumes. Participants were facilitated to share the observations with each other so that concept may be developed regarding emission of brown fumes.

3. Abstract Conceptualisation

As per observation of the participants brown fumes may have been due to NO_2 gas formed by the decomposition of $Pb(NO_3)_2$ as given below:

$$2\,Pb(NO_3)_2(s) \longrightarrow 2PbO + 4NO_2(g)$$

Based on the above discussion participants were facilitated to develop a concept that the reaction in which a single compound splits or breaks into two or more simple substance(s) under suitable conditions is a decomposition reaction, so the above reaction is an example of a decomposition reaction.

4. Active Experimentation

After conceptualisation of the decomposition reaction, participants were further facilitated to perform the following activities and record their observations:

(i) Take $(NH_4)_2\,Cr_2O_7$ on a white tile and burn it with the help of a match stick.

(ii) Take some ferrous sulphate crystals in a dry test tube. Heat the boiling tube over the flame.

In sharing the observations, participants mentioned that in activity (i) gases are evolved on the burning of $(NH_4)_2Cr_2O_7$ and a scene just like a volcano develops. It was also mentioned that in activity (ii) the light green colour of ferrous sulphate crystals turned to white and the gas emitted has the characteristic odour of burning sulphur.

Further, it was explained that as per observations, gases evolved in activity (i) are due to the decomposition of $(NH_4)_2Cr_2O_7$ as given below and it is an example of a decomposition reaction.

$$(NH_4)_2Cr_2O7(s) \longrightarrow Cr_2O_3(s) + N_2(g) + 4H_2O(g)$$

In the case of activity (ii) it was explained that there is a decomposition of $FeSO_4$ as per the reaction given below:

$$2FeSO_4(s) \rightarrow Fe_2O_3(s) + SO_2(g) + SO_3(g)$$

In the above reaction, the light green colour of ferrous sulphate crystals turns white due to the formation of iron oxide. The sulphur oxides formed in the process is evolved as gas. The process corresponds to the decomposition reaction of $FeSO_4$.

On completion of the desired learning cycle, it was shared by the participants that they have properly learned and enjoyed the experiential

Fig. 3: Experiential learning of chemical reactions

learning of decomposition reactions. Considering the active participation of the participants, they were further facilitated for experiential learning of displacement reactions as discussed below.

Experiential Learning of Displacement Reactions

For experiential learning of displacement reactions participants were facilitated for experiential learning cycle as discussed below.

1. Concrete Experience

Participants were facilitated to perform the following activities and record their observations:

(i) Take about 3 mL solution of sodium sulphate in a test tube

(ii) Add some barium chloride solution to it.

2. Reflective Observations

Participants recorded their observations and it was shared that in the above activity water-insoluble white substance is formed on addition of $BaCl_2$ in aqueous Na_2SO_4.

3. Abstract Conceptualisation

At this stage participants were facilitated to interpret the observation for development of a concept. As per discussion it was revealed that in the above activity following reaction takes place:

$Na_2SO_4(aq) + BaCl_2 \rightarrow BaSO_4(s) + 2NaCl(aq)$

The white substance formed in the reaction is $BaSO_4$ which is water-insoluble. It was also considered during the discussion that

in this reaction, there is an exchange of ions between the reactants and it is a double displacement reaction.

Considering the discussion, participants were facilitated to conceptualise that the reactions in which ions of one reactant are displaced or removed by the ions of another reactant are known as displacement reactions.

4. Active Experimentation

At this stage, participants were further facilitated to perform the following activity and record their observations:

(i) Take about 3mL solution of lead acetate solution.

(ii) Add some potassium iodide solution to it.

Participants shared that in the above activity following reaction takes place:

$Pb(CH_3COO)_2 + KI \rightarrow PbI + CH_3COOK$

The yellow substance formed in the reaction is PbI and it is water-insoluble. This reaction involves an exchange of ions between reactants so it is an example of a displacement reaction.

On completion of the learning cycle of displacement reactions, an interaction was made with the participants to know the extent of thier understanding of the concept and it was found that participants have been successful in getting the experiential learning of displacement reactions.

Experiential Learning of Oxidation and Reduction Reactions

For experiential learning of oxidation and reduction reactions, participants were trained by facilitating the following steps of learning cycle:

1. Concrete Experience

For experiential learning of oxidation and reduction reactions participants were facilitated to perform the

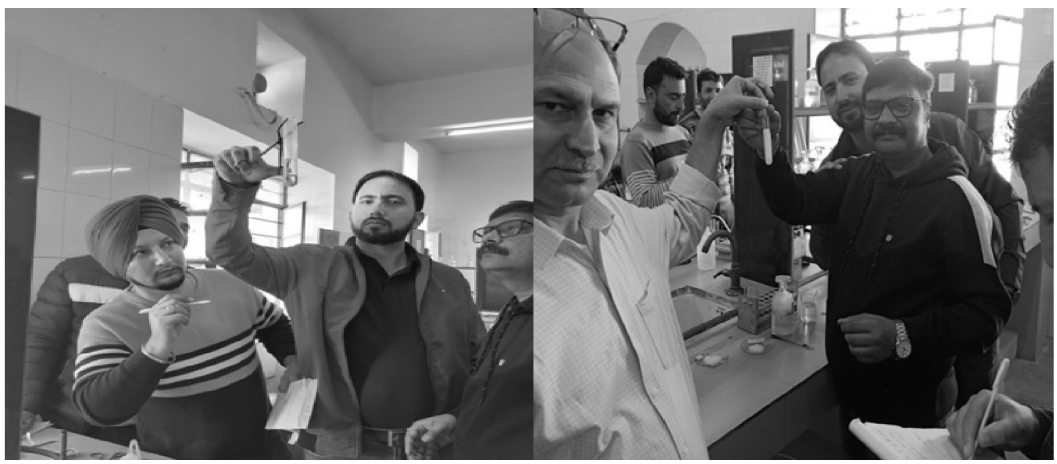

Fig. 4: Experiential learning of chemical reactions

following activities and record their observations:

(i) Take about 1g copper powder in a china dish and heat it.

(ii) Now take zinc granules in a test tube and add some HCl to it.

(iii) Carefully pass the gas produced over the substance formed on heating copper powder using a delivery tube.

2. Reflective Observations

At this stage of learning, participants were facilitated to share the observations of activities performed in the first stage of the learning cycle. It was shared that in the above activity copper powder turned black on heating. When hydrogen gas is passed over the black coating the surface turns brown and copper is obtained.

3. Abstract Conceptualisation

At this level of learning cycle, participants were facilitated to develop a concept on the basis of reflections discussed above. It was discussed that the black coating formed on heating of copper powder was a coating of CuO which is formed by the following reaction:

$2Cu+O_2 \rightarrow 2CuO$

In the second part of the activity, H_2 gas is produced by the reaction of zinc and HCl which reacts with black coating of CuO as given below:

$CuO + H_2 \rightarrow Cu + H_2O$

It means in this reaction copper is again produced.

Considering the reflective observation, participants were facilitated to conceptualise the concept of oxidation and reduction reactions. It was discussed that if a substance gains oxygen during a reaction it is said to be oxidised and if a substance loses oxygen during a reaction it is said to be reduced. In the first part of the activity copper gains oxygen and black CuO is formed; an oxidation reaction takes place. In the second part of the activity, copper oxide loses oxygen and thus, copper oxide is reduced to copper.

At this stage, participants were encouraged to ask questions related to oxidation and reduction reactions. Some related questions were also asked by the investigator to ensure proper conceptualisation of oxidation and reduction reactions.

4. Active Experimentation

After proper conceptualisation of oxidation and reduction reactions at the preceding stage of learning, participants were further facilitated to perform the following activity and record their observations:

(i) Take some MnO_2 in a test tube and add aqueous HCl to it.

Now the participants were facilitated to share their observations. It was shared that in the above activity a yellow-green gas with a pungent smell is evolved. On asking why yellow-green gas with a pungent smell is evolved in this activity, it was shared that yellow-green Cl_2 gas

is evolved as per the reaction given below:

$MnO_2+4HCl \rightarrow MnCl_2+2H_2O+Cl_2$

As per the concept of oxidation and reduction reactions, in the above reaction MnO_2 is getting reduced and HCl is getting oxidised. As per the interaction with the participants concept was well understood through experiential learning.

Feedback from the Participants

In order to know the effectiveness of the present interventions on capacity building of SRGs on experiential learning process, interaction was made with each participant to reflect upon the process of the learning through a questionnaire with questions like:

1. Are you satisfied with experiential learning interventions in chemical reactions during this session? Yes/No
2. Are you satisfied with the experiential learning strategies adopted by the resource person? Yes/No
3. Have you properly understood the concept of experiential learning? Yes/No
4. Please comment on the following components of experiential learning cycle of chemical reactions during the present process:
   - Concrete Experience.....
   - Reflective Observation.....
   - Abstract Conceptualisation.....
   - Active Experimentation.....
5. Please share your experience about this session by indicating your previous experiences about experiential learning strategies.
6. Please share your observations about the session on experiential learning strategies in chemical reactions.
7. Do you feel that after these interventions you are able to handle the experiential learning process in classroom situation in the present session?

In order to know about capacity building of the participants on experiential learning some participants were given a chance to present on experiential learning strategies of a scientific concept of their choice.

An analysis of the observations, data and feedback received from the participants revealed that each participant was satisfied with the experiential learning interventions made through chemical reactions. It was also revealed that the present session has been successful in building up the desired capacity in the SRGs to handle experiential learning process. Each participant showed satisfaction over the experiential learning strategies adopted by the resource person. Some points evolved through interaction and feedbacks received from the questionnaire are as following:

- It was an effective session with a lot of experiences gained through activities and interaction.

- The session was truly based on four steps of the experiential learning cycle.
- Performing hands-on activities in a collaborative manner was a great experience.
- The training was effective and supports in using experiential learning approaches in classroom situation.
- Sessions enhanced confidence to deliver content through stages of experiential learning.
- The experience of recording observations for conceptualisation in experiential learning has been provided.
- Four stages of experiential learning session on chemical reactions was great. This kind of strategy will help teachers in running the process in school.
- We were exposed to the situation and facilitated to follow the different stages of experiential learning. It has made us confident in handling the experiential learning process.
- The session was insightful and helped in going through various contemporary ways through which learning in a classroom setting can be enhanced. I will try to use experiential learning approach in the classroom to get the desired results and achieve learning objectives.
- Many times I have to performed the activities in laboratory many times but without following the actual philosophy of experiential learning. This programme has been successful in giving real sense of experiential learning.
- During the present session we have learned how to involve the students in the teaching-learning process by adopting experiential learning strategies.
- I feel that the adoption of experiential learning approach will enhance my satisfaction than traditional teaching approaches.

Discussion and Conclusion

During the course of present study, interventions were given for capacity building of SRGs to handle the experiential learning process using the concept of chemical reactions. As per the interaction and feedback received from the SRGs, it was revealed that the present form of interventions has been successful in developing capacity in the SRGs to handle the experiential learning process. In view of the above, it may be concluded that properly planned interventions are needed for capacity building of SRGs to handle experiential learning stages and making the process interesting, joyful and student-centric in real sense. Therefore, it is recommended that the present form of experiential learning interventions may be adopted for capacity building programmes on experiential learning process in science.

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