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Student Engagement in Science Classroom: Effect of Inquiry-Based Learning

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Abstract

The present study aimed to find out the engagement of learners in science class when instructed through inquiry- based learning approach. The sample comprised of 157 VIII graders with two different learning approaches viz. student with deep learning approach and student with surface learning approach. The data collected was analyzed with the help of two-way analysis of variance.Findings revealed that engagement of students in science class was boosted up when science lessons were taught through inquiry based learning as compared when taught through conventional method.Moreover, learning approach do not account for difference in enhancement of engagement among students. Further, Students with deep and surface learning approaches when exposed to inquiry based learning and conventional chalk and talk method did not exhibit difference in their engagement in class.

Keywords: Student engagement, Inquiry-Based Learning, Learning Approach

As a subject to be taught and learned in school, science has always posed a challenge for both teachers and learners. Understanding science is difficult for students because it requires a complicated, continuous time and effort. Even if some level of comprehension may drive children to learn, it appears that early engagement with science is a necessity for comprehension and long-term learning, and it goes without saying that student enthusiasm to learn does not ensure comprehension of any subject, particularly science subject (Hadzigeorgiou, 2005a, 2015). In order to provide opportunities for constructing scientific understanding, they have to primarily engage and motivate students with science, its content and techniques. From a multidimensional perspective researcher argues about the different aspects of engagement in the learning environment(Appleton, Christenson, & Furlong, 2008; Newmann, Wehlage, &Lamborn, 1992). Thus, understanding students engagement (i.e., affective, behavioral, and cognitive) can provide educators with more options to pedagogically intervene to promote student learning (Finn & Rock, 1997; Fredricks et al., 2004). Previous research suggests that students with greater affective, behavioral, and cognitive engagement may have higher levels of academic achievement (Fredricks et al., 2004). According to Godec et al. (2018) student engagement is enjoyment and interest, but also as motivation as well as future orientations toward science. In addition it means the degree (frequency) and intensity of students' participation in science related activities.Although the concept of student engagement has been a topic of discussion in the field of educational research for a very long time and its significance are continuously rising. The extent of student engagement during the teaching-learning process is determined by a variety of factors, including internal factors such as psychological constructs like interest and motivation (Renninger&Bachrach, 2015) and external factors such as the nature of family and peer support (Bempechat&Shernoff, 2012) and the role of teachers and their approaches to teaching and interacting with students (Meece et al. 2006; Pianta et al. 2012; Roorda et al.2011). The effect of inquiry based learning was explored by researchers (Brown, 2016; Frezell, 2018; Kuhn et al., 2020; Smallhorn et al., 2015) and reported that using inquiry based learning approach has boosted the engagement of students in learning. Further, researchers (Aycicek&Yelken, 2018; Fatawi et al., 2020; Joseph, 2014; Laura, 2017; Mango, 2015; Manwaring et al., 2017; Rao, 2014; Salam et al., 2016; Soleimani& Abdi, 2021) revealed that instructional strategies viz; questioning strategies (cognitive, affective and metacognitive), positive psycho-educational intervention program, student centric learning process, use of I pad, project based learning, student centered learning, blended learning, flipped classroom and concept map played a significant role in engagement thus promoting active learning. Matthew et al. (2011) found that attributes like social learning spaces, personal attribute of the students, institutional climate, subject of the study, sex difference also can enhance student engagement.

Student Engagement as a Multidimensional Construct

Fredricks et al. (2011) defined "Student engagement is a multi-dimensional, multifaceted construct that includes affective, behavioural, and cognitive dimensions" (p. 10-11).

Cognitive, behavioural, and affective indicators of student engagement is reflected well by Skinner and Belmont (1993) who believe that "students who are engaged show sustained behavioural involvement in learning activities accompanied by a positive emotional tone. They select tasks at the border of their competencies, initiate action when given the opportunity, and exert intense effort and concentration in the implementation of learning tasks; they show generally positive emotions during ongoing action, including enthusiasm, optimism, curiosity, and interest" (p.572).

institutions.

The behavioural dimension covers student's performance or actions that can be observed; e.g.

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participation in co-curricular activities, scores on achievement tests, quality and timely submission of assignments as well as their grades in class. Behavioral engagement is considered crucial for achieving positive academic outcomes and preventing dropping out (Willms, 2003; Jimerson, et al., 2003).

The cognitive dimension relates to students mental investment, comprises students' perceptions and beliefs related to self, teachers, and peers. It incorporates thoughtfulness and a willingness to exert the effort necessary to comprehend complex ideas and master difficult skills (Jimerson, et al., 2003).

In light of this, it can be concluded that student engagement is like an over-arching meta-construct which integrates different and diverse lines of research to explain student success. Researchers and educators have created these various dimensions to make it easier to comprehend and deal with this multifaceted subject, which would otherwise defy one definition and notion.

Student engagement and its importance remain undisputed by educationists and policy makers. It can be seen that engagement has become a significant consideration for educators both as a means of understanding student behaviors as well as performance. It also helps to address student needs individually as well as collectively through system-wide efforts. Although,there is thetrend in the literature in the way student engagement is conceived, due to its multifaceted nature there is still scope for experimenting with what exactly comprises this term. Any one definition cannot do justice to all its dimensions. There are disparities in how student engagement has been measured in addition to the disparity in conceptions of what it means.

According to a review of empirical studies, there are many differences between the types of items used to assess student engagement, the information sources utilized to gather the data (such as students, teachers, and school records), and the structure of assessments (such as surveys and questionnaires) (Jimerson, et al., 2003).Additionally, engagement is not seen as a quality of the student but rather as a state of being that is greatly influenced by the environment, including family and peer relationships as well as the policies and procedures of the institution.

Pertinence of student engagement inthe context of Indian classrooms

It is not always the quality of the teacher's expertise and experience that leads to successful learners; rather, it is the degree to which the students allow themselves to be motivated and engaged in their learning. In other words, the primary requirement for any effective educational system is learners with a true thirst for knowledge. Thus, there is a strong requirement for students to be involved in the educational process. Student engagement assumes to be the greatest challenge for the educators. The need to understand the individual needs of the students, their behavior and performance becomes pertinent (Sharma &Bhaumik, 2013). Lack of engagement leads students to not only withdraw emotionally and cognitively from the learning process, but also learner do not participate in the curriculum, and experience low levels of motivation and interest leading to the "emotional and physical withdrawal of students from school"(Yazzie-Mintz, 2006). Disengagement among students a major concern within the educational setting, which is suggested as an "engagement gap" among students. However, students remaining engaged in the learning process are at low risk of dropping out of school. Thus, it is an utmost responsibilityof a teacherto implement specific strategies and instructional practices to enhance student engagement (Skalsky, 2009).

It has been shown that learners who are emotionally and cognitively engaged in learning invest more time and effort in their studies and are efficient in dealing with the demands of study and display more persistence when facing problems than the learners who suffer from lack of emotional and cognitive engagement (Wang & Eccles, 2011).There has been a significant level of importance given to aspects that are 'inside' students that determine their level of engagement; however, far fewer research have attempted to understand the external factors that shape varying levels of engagement with science and the relationship between them. Thus, both internal and external factors need to be considered.

Objectives

- To study the mean difference scores on student engagement of the students when taught through inquiry-based learning method and conventional method of teaching.
- To compare the mean difference scores on student engagement of students with different learning approaches.
- To study the interaction effect between instructional treatments and learning approaches with respect to student engagement.

Hypotheses

- There exists no significant difference on mean difference scores of student engagement for experimental and control groups.
- There exists no significant difference on mean difference scores of student engagement of students with deep learning approach and surface learning approach.
- There exists no significant difference on mean difference scores of student engagement of students with deep learning approach and surface learning approach when exposed to inquiry based

i) The study was conducted on students of class VIII of Government Model Senior School,

Sector 37-B and Government Model Senior School, Sector 22-A in Chandigarh.

ii) Only six chapters of class VIII science textbook recommended by NCERTwere taken.

iii) Only two types of learning approaches, viz. deep learning approach and surface learning approach were taken.

Method

Sample

The research was carried out on class VIII students enrolled in CBSE affiliated schools in Chandigarh. Out of 115 Govt. Schools of Chandigarh two schools were selected using random sampling technique. Revised Two Factor Study Process Questionnaire (R-SPQ-2F) (Biggs et al., 2001) was administered to 179 students of class VIII. Based on their scores on the R-SPQ-2F, the students were categorized into two groups'viz. students with deep learning approach and students with surface learning approach. 73 students fall in the category of deep learning approach and 84 students in the category of surface learning approach. The students with deep learning approach and surface learning approach were randomly assigned to the experimental and control group. Thus, the total numbers of students in both the schools included in the study were 157, out of which 78 students were in the experimental group (37 deep learning approach and 41surface learning approach) and 79 students were in the control group (36 deep learning approach and 43 surface learning approach).

Design

The study was experimental in nature and pre-test post-test control group design with one experimental group was employed. In the experimental group, students were instructed using inquiry-based learning, while in the control group; students were instructed using traditional method. On the basis of their achievement, both groups were assessed before and after the treatment. The same achievement test was administered to both the groups after the gap of 25 days to obtain the scores on retention. During teaching intervention, students worked in small groups where they were encouraged to share their ideas, discuss their observations and interpret findings of the experiments carried out with the classmates.

2X2 factorial design was analyzed with the help of ANOVA for difference scores on student engagement. Here instructional treatments and types of learning approaches were independent variables and difference scores on student engagement was the dependent variable. The variable of instructional treatment was studied at two levels i.e. experimental group (T_1) and control group (T_2). Learning approach was studied at two levels viz. deep learning approach (L_1) and surface learning approach (L_2).

Tools used

Following tools were used for the present investigation by the researcher

1. Inquiry Based Learning instructional material/ lesson plans based on the chapters covered from the syllabus of class VIII science text book prescribed by NCERT, New Delhi in 2008. The chapters included were: Combustion and Flame, cell Structure and Function, Reproduction in Animal, Force and Pressure, Friction and Chemical Effect of Current.
2. Worksheets (developed by investigator)
3. Student engagement scale in science (developed by the investigator) . It comprised of 48 items. The items assesssed students' cognitive, emotional and behavioral engagement.

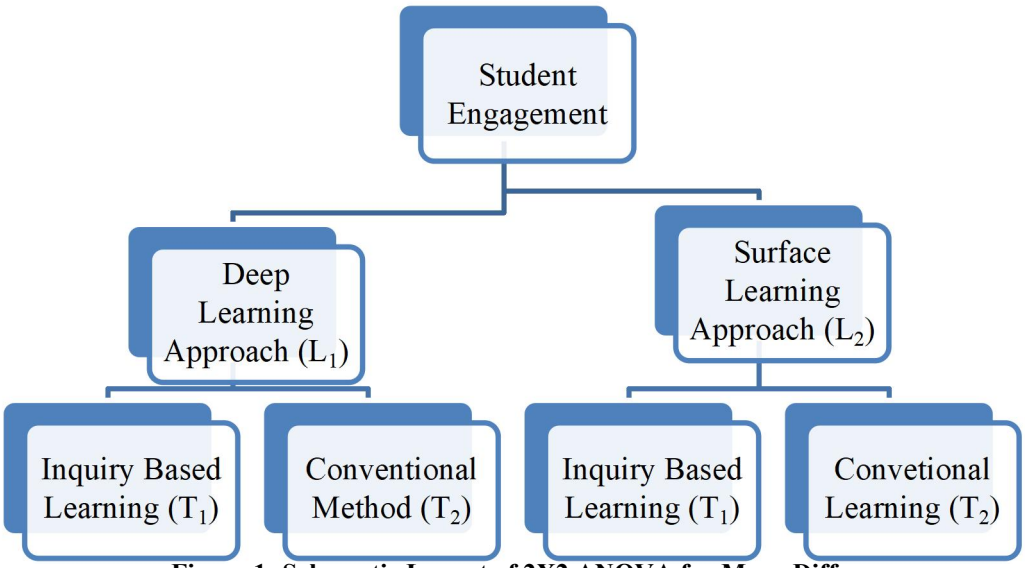

Figure 1: Schematic Layout of 2X2 ANOVA for Mean Difference on Student Engagement Scores

4. Reliability of the test was calculated by Cronbachs's alpha and Guttmann split-half coefficient and found to be 0.88 and 0.83 respectively.
5. Revised Two Factor Study Process Questionnaires (R-SPQ-2F) (Biggs et al., 2001)

Procedure

The experiment was conducted in four phases:

Phase 1: Administration of Pre-test

In this phase the student engagement scale in science was administered to the students of the experimental group and control group. Students response were scored with the help of scoring key.

Phase 2: Conducting Actual Instructional Program

For Experimental group

First day of the experiment was started by the introductory session to build up rapport with the class in the presence of science teachers of the respective class on the same day.

Inquiry based learning instruction was incorporated in to the teaching learning process to find out the efficacy of the treatment variables. The control group received instruction using the traditional chalk and talk method. Both the groups were taught 6 chapters of class VIII science lessons prescribed by CBSE/NCERT, and were taught same content throughout the sessions.

Instructional Program for Inquiry Based Learning

Following steps were involved in introduction of Inquiry Based Learning approach to the students:

a) Introduction of lesson
b) Working in the groups
c) Conducting formative tests
d) Reward
e) Review process
f) Re-teaching

Teaching Lessons with IBL

The inquiry based lessons were prepared by utilizing 5E Model. This model includes five stages (Bybee et al., 2006; Llewellyn, 2007). The period of 50 minutes was divided according to the requirement of each phase as shown in the table 4.3.

During engagement phase

Investigator will orient students towards the new concept by giving a brief introduction about the lesson to be studied. The teacher assessed the learner's prior knowledge by asking questions or performing short activity to engage student in new concept to be taught. The engagement phase means channelizing student's Attention and focus (Llewellyn, 2007).

b) **Working in the groups**: Students were divided in to group of six and one student from each group was designated as leader rotation wise. For the purpose of group discussion it was requested that team members move their work places closer enough to work together as a group. Students were instructed regarding the precautions to be taken while working in the laboratory. Investigator distributed material like common substances available at home and required apparatus and chemicals from lab to each group related to the experiment for the exploration phase. Worksheets associated with each lesson were also distributed for writing observations and other responses.

All the students were given following instructions for working in the group:

i) You are divided into the group of six.
ii) One student from each group will be assigned to the role of group leader on the rotational basis.
iii) Each student in group should perform the activity and write own observations. However, you are allowed to discuss with your group member or take assistance from the text book.
iv) Team members are expected to express their disagreements and work together to fix the problem if any. When students are unable to fix the problem on their own, they should seek assistance from the teacher.
v) Every now and then, encourage and congratulate your pals on their accomplishments.
vi) All the students should follow the instructions given by the teacher regarding the handling of lab materials, objects etc.
vii) Do not touch the apparatus in the laboratory without the permission of teacher.

Analysis of mean difference scores on student engagement scores

Table 1: Means and SD of 2X2 Analysis for Mean Difference Scores on Student Engagement

Treatment	Learning Approach	Mean	SD	N
Experimental Group (T_1)	Deep Approach (L_1)	34.38	22.59	37
	Surface Approach(L_2)	26.51	19.76	41
	Total	30.24	21.38	78
Control Group (T_2)	Deep Approach (L_1)	20.31	12.67	36
	Surface Approach(L_2)	19.77	12.91	43
	Total	20.01	12.72	79
Total	Deep Approach (L_1)	27.44	19.58	73
	Surface Approach(L			
	Total			

a) **Introduction of lesson**

During exploration phase

Students are required to collect information and perform hands on activity with the given material provided to them and write down their observations on the worksheets as per instructions given on the worksheet. Students worked without the instruction of the teacher at this phase but may take help of the textbook wherever necessary. While students were working in groups, the investigator walked around the classroom, praised groups that were doing well, and sat down with each group to hear and observe how individuals were doing. Students were allowed to peer-review each other observation and discuss in groups and help each other in understanding the concept during the process through discussion with material provided by the teacher as live objects, events, situations and activities etc.

During explanation phase

At the completion of worksheet and activity performed, group leader from each group was told to present and summarize their observations and share results in front of the whole class. Explanation phase is the appropriate time for the teacher led instruction also. The investigator coordinated the presentation of each group and explained various terminologies related to the concept taught and detailed information about the topic which leads to the chance to expose students in new situations. The investigator supplemented this stage with the audio visual resources and activities.

During elaboration phase

Students were asked to apply the learned concept in the real world situations outside the classroom like citing examples and reasoning question from the real situations. This phase was accomplished by encouraging students to apply their understanding of the concept by solving application based problems in the given worksheet.

During evaluation phase

Evaluation was done on the basis of students performing hands on activity in the group and making observations, recording and providing responses in the blank worksheet.

Investigator identified and monitored skills used by students as they investigated solutions to their questions on the worksheet through monitoring chart (appendix I). Performance of behaviors is recorded on a monitoring chart by using letter grades (E= Excellent, G=good, F=fair, N=not observed).

c) **Conducting formative tests:** After covering a lesson in about 2 or 3 days, a formative test (multiple choice questions and constructive response questions e.g. fill in the blank items, short answer question) was conducted. Number of formative assessments was devised based on the length of the chapter. Students were given ample time to finish the test. They were not permitted to work on together. Total fourteen formative tests conducted throughout the study. A great deal of effort went into making sure that the tests were able to do credit to each topic.

Reward: The results of each formative test were announced in front of the entire class. Those students who scored high marks in formative tests were assigned badges like “Junior Scientist”, “scholar”, “perfect score”etc.

Review process: Students were instructed to reflect on the work that they had done in their group after they had finished their group activity and completed the assessment activity. The students provided input to the teacher on what worked and what did not work well, as well as what they thought was beneficial about the topic. Students' opinions were solicited verbally after each lesson.

Re-teaching: Those parts of the lesson that had been reported to be poorly comprehended by the majority of the students were taught again using the same approach, but with different examples and objects to improve in comprehension.

In all, students were taught 35 lessons covering six chapters.

For Control Group

The control group was also taught same topics through conventional chalk and talk method.

Phase 3: Administration of the Post-Test

After the instructional procedure was accomplished the post-test was immediately applied to both the experimental and control groups to assess the effect**.** The response sheets were scored with the help of scoring key.

Main Effect

Table 2: Summary of ANOVA of Mean Difference on Total Scores of Student Engagement Scale

Source of Variation	Sum of Squares	df	MSS	F-value	p-value
Treatment (T)	4230.042	1	4230.042	13.887	.0001**
Learning Approach (L)	689.425	1	689.425	2.263	.135(N.S)
Interaction (T x L)	524.160	1	524.160	1.721	.192(N.S)
Error	46604.260	153	304.603		

N.S- Not Significant **- Significant at 0.01 level *-Significant at 0.05 level

Treatment (T)

F-ratio (Table 2) for mean difference scores on student engagement of the two instructional treatments was

approach exhibited better student engagement as compared to conventional chalk and talk method.

Learning Approach (L)

F-ratio (F=2.26; p=.13≥.05) for the mean difference scores on student engagement for the learning approach was found to be not significant even at 0.05 level of confidence. It can be inferred that deep and surface learning approaches exhibited comparable scores on student engagement.

Interaction effect between treatment and learning approach (T x L)

The interaction between treatments and learning approach was found to be not significant even at 0.05 level of confidence (F= 1.72; p=.19≥.05). It implies that there is no interaction between the two variables. The two variables, treatment and learning approach were found to be independent of each other. It implies that student with deep and surface learning approaches when exposed to inquiry based learning and conventional chalk and talk method did not exhibit enhancement in student engagement.

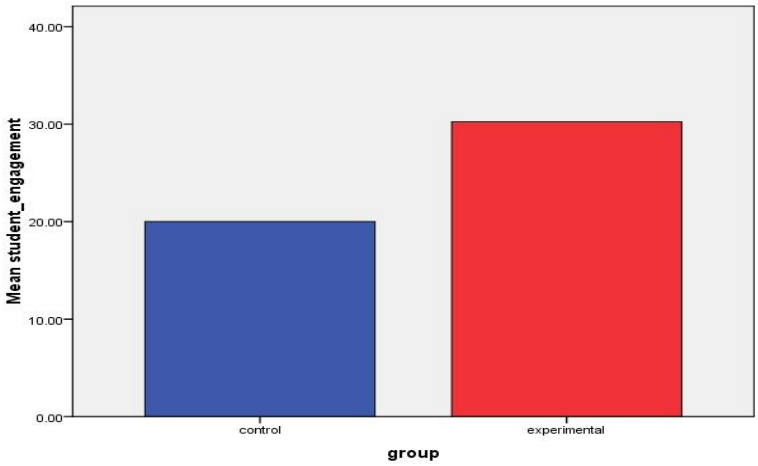

Figure 1: Graphic Representation of Mean Difference Scores of Student Engagement

Discussion of Results of Scores on Student Engagement

In this paper the analysis of effect of inquiry based learning approach on student engagement has been discussed. Students' engagement in class or schoolwork, which has been shown to influence outcomes such as student performance satisfaction, rises significantly and meaningfully when they are informed why they are learning the concepts and how they may be used in everyday life or real-world scenarios (Chernus& Fowler, 2010).As F-ratio for the mean difference scores on student engagement for two instructional treatments was found to be significant at 0.01 level of confidence. Students when taught through inquiry based learning resulted enhancement of engagement in class as compared to conventional method.The results are consistent with the results of researchers (Brown, 2016; Frezell, 2018; Kuhn et al., 2020; Samllhorn et al., 2015) where student engagement is enhanced by use of inquiry based learning method.Whereas other researches shows that student engagement is also enhanced by teaching through positive psyche-educational intervention program PPEI (Joseph, 2014), student centric learning (Rao, 2014); use of I pad (Mango, 2015), project-based learning approach (Salam et al., 2016), student centered learning programe (Goldman, 2017), blended learning (Manwaring et al., 2017), flipped classroom model (Ayçiçek&Yanpar-Yelken, 2018; Soleimani& Abdi, 2021), concept map (Fatawi et al., 2020).As F-ratio (F=2.26; p=.13≥.05) for the mean difference scores on student engagement of students with deep and surface learning approaches was found to be not significant at 0.05 level of confidence. Learning approach do not account for difference in enhancement of engagement among students.As F-ratio (F= 1.72; p=.19≥.05) for interaction between treatment and student engagement was found to be not significant. It implies that students with deep and surface learning approaches when exposed to inquiry based learning and conventional chalk and talk method did not exhibit difference in their engagement in class.

Conclusion

This study offered an ideal opportunity to obtain a comprehensive understanding of students' engagement in the classroom environment of inquiry-based learning. According to theory, student engagement has several components viz., behavioral, cognitive and emotional components. These components can be shaped by pedagogical intervention.Asthe research emphasizes the need of learner's engagement in relevant science courses. Instructional material ought to result in required standards of concepts and their application to actual circumstances.Teachers should ensure that the teaching-learning process fosters relevance and contextualization, stirs interest, stimulates curiosity, and inspires learners to discover new things when creating a Science lessons. Students' interests and involvement are surely grabbed and sustained by the usage of real materials, as they appreciate and study things that are related and relevant to their day-to-day living. Science education methods should include investigation of the natural or material world, which leads to inquiring questions and

making discoveries through collaborative learning activities. Furthermore, students should be encouraged to participate and engage during small-group discussions in Science, so that they can share their perspectives and information not only with their classmates but also with their Science teacher. Science inquiry, which is based on constructivist learning theory, generally adheres to the scientific method of allowing students to acquire and grasp science subjects through experimentation, real-world, and practical experiences. The study revealed that greater levels of student engagement were linked to learning activities where participants had a choice. Furthermore, the research contributes to the understanding of several aspects of student engagement in inquiry based learning approach in the context of school education. It was observed that the pedagogical decisions made by an instructor appear to have a greater impact on student engagement than the learning activity or the learner's particular qualities. Learning activities that provide students choices, foster socialization, are viewed as essential by the student, and are seen as relevant or related to prior student knowledge are all correlated with higher levels of student engagement in the subject being taught.

Last but not the least the research has solidified our belief that inquiry based learning has the potential to improve student engagement in science.The versatility of instructional activities encourages student autonomy, value judgments, and choice while fostering regular interaction between the student and the teacher. The students will be thoroughly engaged in the learning process and motivated to attend and participate actively in their Science class every day if the teachings and performance tasks are realistic and contextualized.

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