

An Innovative Strategy for Addressing Diversity in a Science Class

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Abstract: A project called 'Science Education and Diversity' (SED) funded by the European Union's FP7 programme was initiated by the University of Exeter in 2010 and was simultaneously conducted by the six partner countries, namely UK, Netherlands, Turkey, Lebanon, India and Malaysia. The Indian chapter was conducted by the Homi Bhabha Centre for Science Education and was completed in 2012. It aimed to understand the relationship between science education and diversities. The present paper gives a broad summary of phase three of the project which was an intervention carried out in 3 secondary schools of Mumbai, where the topic "Biological diversity" was taught to class VIIIth students. Using a design based pedagogical framework an attempt was made to use the topic to also address the diversities in human beings (gender, religion, culture, etc). The pre-intervention findings showed that teachers largely ignored addressing diversity in the classroom in their teaching-learning activities. Post-intervention too there was not much change observed in the teachers' stance. The paper provides implications for addressing diversities through the school curriculum.

Key words: diversity, science, gender, religion, culture, intervention

Introduction

Homi Bhabha Centre for Science Education was involved in an international project called *Science Education for Diversity* (SED). The main aim of this project was to analyze how the involved countries namely Lebanon, Turkey, UK, Netherlands, Malaysia and India were addressing diversity (religion, caste, regions, languages, religions, socio-economic classes, habitation and gender) via science education.

The project was conducted in three phases. The first phase consisted of studying the educational policies of the country regarding diversity and science education. The second phase assessed the attitudes and views of students and teachers regarding diversity and

science education. The present paper provides highlights of the third phase which involved an intervention in a few schools. The main objectives of this intervention were:

- Developing a pedagogical theoretical framework to make science education suitable for diverse learners.
- Providing training to teachers regarding the different aspects of this framework.
- Devising activities to engage science teachers in teaching science to culturally diverse students.
- Developing an understanding of the issues that need to be addressed when attempting to transfer good practices suggested by the theoretical framework into different settings.

Science and Diversity: The relationship

While science is depicted as being objective, non-negotiable, culture and value free by most science curriculum (Schwedes, 2008) it is pertinent to note that the interaction between different aspects of diversities do affect attitude towards science as well as science outcomes (Lee and Luykx, 2006). According to Driver et al., (1992) personal experiences and environments shape the way the students understand the natural world. When students from diverse cultures come to school they bring with them an already constructed knowledge structure that includes their home language, their cultural experiences as well as the values they learn as a part of their family and community life. Their experiences may at times differ or be antagonistic to what they learn in their science classes.

A study by Lawson and Thompson (1988) has indicted that students do possess alternate conceptions regarding scientific ideas that have roots in their personal experiences and backgrounds and could be potential obstacles in the path of learning. The situation wherein students in their science classes carry ways of knowing that are different from science perspective can be challenging as there is discontinuity of students knowledge with nature of science or way science is taught in school (Atwater, 1994 and Gallard, 1993). In the face of such discontinuities between scientific views and cultural experiences, the students need to continuously shift between their already constituted knowledge derived from their cultures and the scientific knowledge offered in the school environment if they do not want to abandon either of them.

Addressing diversity in the Indian education context

Look at the Indian scenario one finds that students in India education system are viewed as a homogeneous mass and subjected to a uniform curriculum which does not pay much attention to diversity on the country (Chunawala and Natarajan, 2012). Along with lack of basic and infrastructural resources there are also huge urban rural disparities and lacunae in the curriculum (India Science Report, 2005).

The National Curriculum Framework for Teacher Education (NCFTE),2009 while reviewing the status of school education does point out the regional, social and gender disparities still continue to pose challenges and the need now is of teachers who can integrate integrate academic learning with social and personal realities of learners and responding to diversities in the classroom. NCFTE further envisions a teacher education curriculum that reciprocates to diversities.

A report titled 'Inclusive Classroom, Social Inclusion/Exclusion and Diversity: Perspectives, Policies and Practices' by Deshkal Society, Unicef India and Care India came up in 2010. This report has recognized several key concerns that policy makers and practitioners in Indian education system need to focus on like recognizing the increasing flow of children with wide range of diversities into the educations system and this bringing forth several challenges and issues that need to be recognized first. The study also suggest that school based practices and processes in the wake of such diversities needed to researched into which could aid in developing effective pedagogical strategies and practices. These teaching learning practices need to be regularly evaluated and feedback is to be generated leading to improvisations.

Design based Framework of Intervention

Design-based research is a cyclic process which leads to transforming the theoretical framework of teaching-learning into novel and effective learning situated in the context of the local educational settings, and consequently increasing potential for educational innovations (The Design-Based Research Collective, 2003). For our intervention the design based framework developed focused on a “guided collaborative critical reflection on action as method of CPD (Continuous Professional Development of teachers)”. It highlighted the following aspects in teaching-learning:

- Relevance of teaching material which can be
 - Controversial issues-based
 - Science related events in the media
 - Everyday world of students
- Guided Collaborative Inquiry based Science education
- Dialogic Teaching---Teaching for and through dialogue involving
 - Argumentation
 - Responsiveness to multiple voices
- Critical Epistemology: Reflection on ways of knowing
 - Reflection on one's own thinking and assumptions

The Intervention phase

The intervention programme was also divided into three phases:

- *Phase I: Pre intervention phase*
 - Classroom observations and teacher and student questionnaires and interviews
- *Phase II: Intervention phase*
 - Lesson planning and execution
- *Phase III: Post intervention phase*
 - Feedback

A brief outline of these phases is given in the flow chart below (Fig. 1). As seen from the framework, data was collected in all the 3 phases of the intervention. The collected data was both qualitatively and quantitatively analyzed.

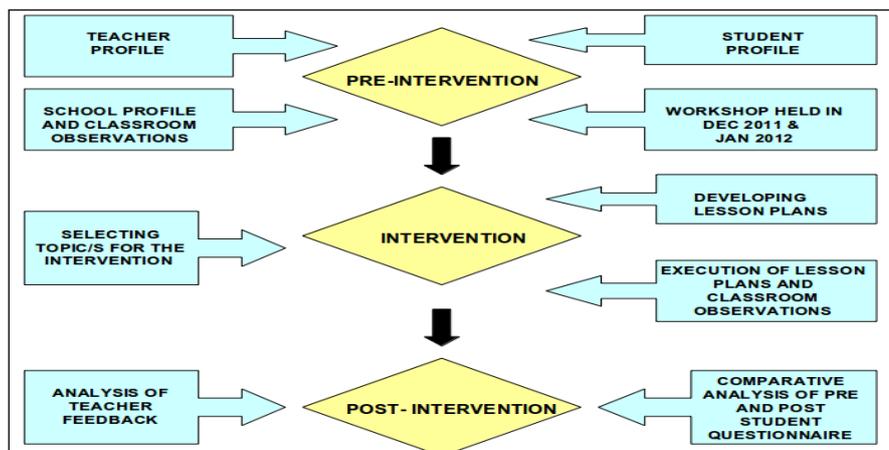


Figure 1: Outline of the procedure

As a part of the project, an intervention was carried out wherein science lessons were planned and taught in a way to sensitize teachers and students to diversities. This paper gives an account of one such intervention programme where the topic '*Biological Diversity*' was taught to class VIIIth students in three English medium schools of Mumbai district. The choice of this topic was made by the teachers. In our workshop with teachers we initially introduced them to our framework and once the topic was decided by consensus, activities were planned and shared by all 4 teachers (3 female and one male).

Research Question: What kind of interventions would help bring about meaningful engagement in integrating issues of science education for diversity in the curricular context?

Methodology: As a part of the project, an intervention was carried out wherein science lessons were planned and taught in a way to sensitize teachers and students to diversities.

Sample: The sample size in this study was 161 students from 3 English medium schools of Mumbai district with 43% being girls and 57% being boys. The sample of teachers consisted of 3 female and one male.

Tools used were researcher's checklist and teacher feedback questionnaire.

Researchers' check-list: This check-list was used during the observation of the transaction of the lessons in the pre intervention phase and during the intervention phase. It had various items which were related to different aspects of the classroom teaching like: About the classroom, Form of address in the classroom, Classroom situation, Methodology of teaching, Topic and Teaching, Quality of delivery, Behavior in the classroom, Classroom interaction, Students' contribution to the lesson, Nature of science and Issues of diversity.

Teacher's feedback questionnaire: Post intervention a questionnaire was given to each teacher to get their feedback regarding different aspects of intervention like about lesson plan and its implementation and science education and diversity. There were total of 27 questions under these sections which were aimed to know the kinds of diversities teachers perceive in their classroom, whether before intervention they addressed these diversities via science teaching or not, which stance does the teacher adopts while dealing with diversities in the classroom. Further it aimed to know teacher's views on the lesson plans made for intervention programme, their involvement and satisfaction level in preparing the lesson plan as well as the shortcomings of the intervention programme. They were asked about the issues and areas

which were addressed through the lesson plan and also the type of diversities which the lesson addressed.

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Session I: Introductory session on Biological diversity

The lesson began by assessing the previous knowledge of the students through questions which tapped experiences of students and allowed discussion such as:

What form of structure/growth appears on the moist piece of bread if left in a room for few days? Is this growth living or non-living?

Through examples given by both teachers and students, a discussion was initiated regarding the diversities that exist on earth. The discussions focused on inter and intra species differences in diversity. As an example of intra species differences, the teachers asked the students to identify the diversities amongst themselves. The teacher prompted the discussion by asking: “Do all of us in this classroom look alike?” and then asked them to state the differences and the similarities. Some of the differences referred to the color of hair, skin, eyes, shape of face, height, sex, etc. A worksheet on different traits and the variations in them across people was given to students to fill and later discussed.

A few examples from the worksheet

Feature	Variation	Indian	Chinese	African	American	Tundra region
Colour of eyes	Black					
	Dark Brown					
	Light Brown					
	Green					
	Blue					
	Other					

Feature	Variation	Indian	Chinese	African	American	Tundra region
Height	Short					
	Medium					
	Tall					

Session 2: Relating biodiversity to human diversity

The session began with the teachers referring to some non-physical aspects among students that also differ, such as culture, ethnicity, language, belonging to a certain region and religion. An argument was initiated around the following topic in order to dispel some gender associated myths.

a) A common myth is that brain size is related to intelligence and since females have comparatively smaller brains so they are less intelligent.

Interestingly students were able to point out the flaws in this argument. A small excerpt from the discussion in one classroom is presented:

Teacher - *So do you think brain size and intelligence are related?*

Students- *No.*

T: - *Can you please tell me why you think like that? Give me your ideas.*

S1(Girl)- *it depends on the knowledge of the person, not on the brain size.*

S2 (Boy)-*The person needs to know how to learn and become intelligent....Even if you have large brain, you should know how to learn.*

T- *So, if one has larger brain, then one can store more information, hence more intelligent?*

Students in chorus- ***NO!***

b) Flash card activity

A set of flash cards (10 each) for the life forms in 7 categories Pisces, Amphibia, Reptilia, Aves, Insects, Plants and Mammalia were made. Another unique category unique was a

collection of human beings (both men and women) from all over the world- South American tribal, people from Tundra region, Caucasians, Middle Eastern people, Chinese, Indians and Africans. They differed from each other from the color of their skin (white, brown, black), hair color (red heads, brunettes, black hair, blonde), color of their eyes (black, brown, green, blue), height, weight, stature, physical features etc.

The students were divided into groups and each group was given a set of flash cards of a life form and a worksheet. The group task was to first find out the similarities between the photos on the flash cards and then the differences between them.



Picture 1: Students working in groups with flash cards

The aim of this activity was that students would be able to distinguish between inter-species and intra-species diversity. For example, students were expected to notice that there are different species of fish, but there are similarities among the different species. Thus they would be able to identify difference among various species and also identify differences that can be seen within the same species.

In case of the set of flash cards about human beings, the teachers pointed out that apart from physical differences many of the differences were cultural arising out of differences in dress/ornaments, among people of different ethnicity, region etc. Another aim of this activity was to get students to work together in groups and defend the points over which diversity exists. There was lot argumentation, debate, collaborations and student-group interactions along with peer learning. One question in the worksheet was interesting and was aimed at getting students insights into how they themselves feel about living in a diverse society. The question was as follows:

Would you like to live in a community where all human beings- Look and talk in the same way									
Yes	<input type="checkbox"/>	No	<input type="checkbox"/>	I	don't	know	<input type="checkbox"/>		
Follow the same religions and custom	Yes	<input type="checkbox"/>	No	<input type="checkbox"/>	I	don't	know	<input type="checkbox"/>	
Have same opinions/views	Yes	<input type="checkbox"/>	No	<input type="checkbox"/>	I	don't	know	<input type="checkbox"/>	
Give reasons for your answer.									

Most of the students felt they would like to live in communities which are diverse and marked “no”. Through their answers it was clear that they did understand that people are different i.e. they speak different language, follow different religion and hence there should be tolerance towards accepting this diversity. They felt that living with diverse people would provide them opportunity to learn and gain knowledge about different and new things. One student voiced that we require diversity because diversity allows us to have choices in our life. According to another student, if everybody is same then how can people get to know about new things? Some students stated that if everybody would have followed same religion and same customs then it would have not been possible to know about the good things about other religions and there would have not been any novelty in festivals. A few students were not in favor of living in a diverse atmosphere mostly because of the conflict factor and worry over violence. Many among them were of the opinion that following same language or religion and having same opinion would help to increase unity among people and would also decrease discrimination that takes place against anyone in the community.

c) Gallery walk

Students were asked to bring forest products from their homes. Students were quite excited and brought a range of items from medicinal to objects of everyday use that are used by almost everyone.



Picture 2: Forest products brought by students and the Forest Products displayed for Gallery walk

These objects were all arranged and the students had a gallery walk where they saw the wide variety of products brought by others. The teacher pointed out that forests serve us in so many ways and a decline in their numbers can bring in shortages of these products and disrupt harmony. The decline in forests due to humans was consciously linked by the teacher to the declining female sex ratio in India which is also cultural and not biological. Another activity was undertaken wherein a map of India was displayed. Post-its having male/female ratio of different states of India written on them were given to students and they were asked to place these post-its to the corresponding states on map of India. The activity increased students familiarity with the states of India and male female ratios in differing states. The teacher discussed reasons for the unequal ratios and differences in states regarding male female ratios.



Picture 3: Map of India with sex ratio post-its put by students

Classroom observations during the intervention

The lesson plan was designed to facilitate dialogic teaching. Dialogic teaching is a two-way process which improves teacher and student communication as well as student-to-student communication. It is also a medium through which students can sharpen and elaborate their thoughts. When a teacher uses this type of pedagogy, it can lead to shared knowledge and better understanding of the domain (Bereiter and Scardamalia, 2005).

A form of dialogic teaching, that is, argumentation, was given particular importance in our lesson plans. Students in an argumentation process will try to articulate reasons for supporting their claim, in an attempt to convince others of the same. The process also involves expressing doubts, asking questions as well as considering and highlighting alternate views (Driver, Newton and Osborne, 2000). The pre-intervention phase questionnaires indicated that most students never argued with their teacher even if they had some doubts/disagreements regarding what was taught during science classes.

The lesson plan had activities, such as debates and group work which facilitated dialogic interaction between students. Teachers did initiate questions and also allowed students to raise questions and argue their reasons with other students as well as with the teacher. The classroom observations during intervention showed that dialogue between teacher-student, student-student and student-group increased considerably.

The views of teachers regarding diversity and the programme to address them

The teachers had a neutral stance on gender diversity. They felt that there was no need to focus on the different interests or experiences of boys and girls and they claimed that students were students and science was neutral. When teachers were asked prior to the intervention regarding the kind/s of adjustments they made in their teaching on account of cultural differences amongst their students it led to some interesting findings. One teacher had actually previously never made any adjustments but would like to do so now while another teacher accepted that though he did make some adjustments these were limited.

After observing the classroom situations in pre intervention and intervention phase as well as interactions with teachers, reviewing their responses in the phase two, it was gathered that the teachers did not reflect on diversity amongst students and the role it could play when they were planning for the teaching learning process. According to researchers that have dealt with instructions which have been culturally relevant, a teacher can address the interests of their students and help in skill building if they have knowledge regarding the students' socio ethnic

cultures, their values as well as their languages and literary practices (Abt-Perkins and Rosen, 2000).

Evidences regarding students understanding and making progress in the lesson

Teachers were asked what evidence they had that students had made progress in the lesson taught during intervention. Teachers mainly concentrated on evaluating the performance of the students on the basis of some oral or written form of examination and in some cases assignments. Such tests would have focused only on textual and content related information and would have been confined within the boundaries of the text of the chapter. What the teachers failed to appreciate was that the intervention was not meant only to make the students merely know the contents of the chapter which would have happened even in the regular classroom sessions.

Berry (2006) in a study on teachers' assessment practices for classroom diversity found that teachers were more concerned with the academic needs of students in comparison to social and affective domains. The aim of the present intervention was to make teachers respond to the diversities in the science classes and help students become aware of these and also be able to have a voice.

Implications

The role of teachers is crucial in terms of generating a population of students who are well equipped to handle diversity. There is a need for teachers to plan lessons in such a way that these allow for linkages with gender and cultural diversity. However teachers are themselves unsure that this is a legitimate step that they should undertake. This clarity can be achieved if there are attempts made by professional teaching institutes to initiate analysis of the curriculum for the professional teacher training courses in terms of making the would-be teachers sensitive to issues of diversity and equipping them with strategies to deal with it. Attempts need to be made to design modules for in-service and pre-service teachers regarding how to address diversities within the curriculum. Researches also need to be conducted in areas such as;

- Survey of the effect of the multicultural backgrounds, linguistic abilities, religion and regional disparities, gender, socio-economic status of students on teaching and learning.
- Reviewing of the best practices evolved in different countries in terms of dealing with diversity via science teaching and evaluating their feasibility in the Indian context.

- Correlation studies on teachers' effectiveness in dealing with diversities with factors like teaching experience, teacher's own culture, ethnicity, gender and native language as well as kind of professional preparation program could be conducted.

Conclusion

Diversities of all kinds are a feature of heterogeneous Indian classrooms. Though it may seem on the surface as an issue that has no direct bearing on learning, research has indicated that diversities (religion, culture, region, gender, etc) influence how students learn in a classroom. The scene in a diverse classroom should boast of rich spaces for dialogue, platforms for bringing and appreciating diverse viewpoints and of course suitable pedagogy and culturally responsive and sensitive curriculum. The most crucial aspect of curriculum for a diverse class has to be its deliberations on the interconnectedness it should have with the students' diverse experiences and exposures. There is need to develop ways and means through which the curriculum responds to these diversities in a constructive way. For successfully teaching children who are diverse it is important for teachers to develop knowledge and skills and realize that "all children can learn" (Banks et al., 2005, p.270). While this paper explored linkages of a topic in science curriculum, the findings of the study were encouraging and suggest that there is a need addressing them through curriculum a serious thought.

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