Future Indian Citizens' Position of Intention towards Nuclear Power Plants Influenced by Beliefs and Understanding: An Intervention Study

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Abstract

Nuclear energy is considered as a future sustainable energy resource in power hungry and fast developing Indian economy. Public understanding of advantages and disadvantages of nuclear power is a key for governments to make informed decisions and actions. Too there are propaganda, misconceptions and politics for and against installing nuclear power plants in India. This study is conducted among 100 secondary students (age group of 13-14) from private, state and central government schools and in their last years of secondary schooling, considered as future Indian citizens. Study specifically looked at their beliefs, understandings and intentions about having Nuclear Power Plants. This research used a design based research method and focused on what beliefs, understanding and intentions future citizens in India have, towards generating power from Nuclear Power and to what extend a 5E model intervention programme can influence it. The questionnaire used was based on theory of reasoned action and the structured intervention lessons used the 5E instructional model as a framework. The data analysed qualitatively and quantitatively, and the qualitative data were coded into categories based on responses. These responses to beliefs, understanding and intentions were analysed to show their inter-relationships using the Structural Equation Model (SEM). Overall findings indicate that before the intervention future citizens' believe and understand that Nuclear Power plants are harmful to the society and at the same time, needed for the economic development of the country and had misconceptions about the safety of the Nuclear Power Plants. Study showed a shift in their position after the intervention. The data analysis using SEM showed that there is considerable change in their beliefs, understandings and intentions before and after the intervention and the changes are not unique in all cases. These differences were depended on the type of institutions (State, central government and private schools).

Keywords: Beliefs about Nuclear power plants, 5E Model, Science education, Public decision making

Introduction

Scientific knowledge can be achieved by the cumulative experience of knowing how by doing it. In most case, it is achieved by participating in the practical research group. Research can therefore be seen as a way of learning. Universities have long abandoned the accent on research and have become mere teaching centres. Research aptitude in students is not properly developed during their course of study. Their curriculum is neither research oriented nor updated. For many reasons majority of teachers with doctoral degrees in science are unwilling to undertake research projects or collaborative research.

C V Raman said that there is nothing intrinsically inferior with the quality of the Indian mind when compared to that of a Teuton or an Anglo-Saxon. Rather, he added that what inhibits us is the lack of a certain courage that would allow us to explore unusual avenues. To this I will add that the average Indian lacks a constructive curiosity and interest in goings-on around him or her. The Indian is far too self absorbed and believes that there is no need to know about many things because it does not help him or her to address an immediate, personal concern. Courage and curiosity are, however, the two essential attributes of a good scientist and their singular lack in the Indian psyche have contributed in no small measure to the deterioration of our science. This is a big problem we face. It is remarked often that an Indian makes a good student or postdoctoral fellow but a poor scientist when (s)he attempts to do independent research. The Indian is too scared to question authority of any form. He would rather swim along with the current. He does not dare to differ. All this runs counter to the scientific disposition, which proceeds systematically along the route of questioning, formulation, experimentation and verification.

Science education research since the 1980s has focused on strategies to improve science education and develop effective school-based science education programs. Despite these efforts, there has been a decline in science education performance. More recently, the implementation of the National Curriculum Frame work(NCF) in India presents unique challenges for science teachers as they are charged with fostering an inquiry-based instruction through the integration of the dimensions outlined in the Framework.

Although the research topic of students' conceptions and conceptual change was the most frequently investigated one , a declining trend was observed when analyzed by year. Moreover, the research topics related to student learning contexts, and social, cultural and gender issues were also received relatively more attention among science educators.

In recent years, science education started to highlight the use of socio-scientific issues in the teaching and learning process. In fact, the use of socio-scientific issues in education served as an approach to make science learning more relevant to students' lives (Cajas, 1999; Pedretti, 1999). It is a venue in assessing students' learning outcomes and appreciation of the nature of science (Bell & Lederman, 2003; Sadler, Chambers, & Zeidler, 2002;Zeidler, Sadler, Simmons, & Howes,2004).And as an important component in enhancing scientific literacy (Driver, Newton, & Osborne, 2000; Pedretti & Hodson, 1995). In the study of Ratcliffe and Grace (2003), using socio-scientific issues in secondary science classrooms enabled students to identify the strengths and weaknesses of their own reasoning aside from enhancing their awareness on the relationships of science and society (Sadler, 2004; Zeidler, 2005). This teaching approach was useful in developing scientifically-literate individuals who use their scientific knowledge to build a competent community who decides and performs actions and participates in any form of inquiry objectively (Tal & Kedmi, 2006). Also, the inclusion of controversial socio-scientific issues in science lessons had the potential to train students who are objective in their decision making processes (Kolstoe, 2001; Millar & Hunt, 2002; Millar & Osborne, 1998; Monk & Dillon, 2000).

Traditionally, state policies associated with school funding, resource allocations, and tracking leave high poverty school districts with fewer and lower-quality books, curriculum materials, laboratories, and less qualified and experienced teachers. Education needs to change to focus on issues facing the 21st century and on every aspect of daily decisions and actions at all levels (personal and governmental) to secure the future of the planet (UNESCO, 2003).A scientifically literate public could improve the quality of public decision-making and actions. Decisions and actions made in the light of an adequate understanding of the issues are likely to be better than decisions and actions taken in the absence of such understanding. Greater familiarity with the nature and findings of science will also help the individual to question pseudo-scientific information (Royal Society, 1985). Sadler et al (2004) asked high school students to demonstrate their understanding of global warming as presented in two media articles. The results showed that only 47% of students were able to understand and explain the use of data in the global warming articles. Other studies (Detterman& Sternberg, 1993; Haskell, 2001) also point to students lacking skills and strategies in using their scientific understanding into informed decision making about a scientific issue. Issues like greenhouse gas emission and global warming are not included in teaching and learning programs and teachers tend to avoid teaching these topics (Kurup, Hacking & Garnett, 2005).

1.1 5E Instructional Model and Development of Intervention Programme

The 5E instructional model (Bybee, 1997) of teaching and learning focuses on inquiry based science teaching and learning through a constructivist approach. This model enables student learning from their prior knowledge to achieving ownership of the knowledge in a learning journey of a five stage cycle - engage phase to evaluate phase. The Engage stage identifies prior knowledge including alternative conceptions; Explore stage provides authentic learning situations in a challenging way, and hands on activities; Explain stage encourages using correct scientific understanding to explain science phenomena; Elaborate stage enables using concepts in new situations to gain ownership of the knowledge; and Evaluate stage generates an overall picture of learning outcomes. The 5E model was found to be effective in the curriculum development process and producing units of work on variety of topics. Primary Connections (Australian Academy of Science, 2005) used the 5E model in their units and found that teachers could use the model effectively to enhance their confidence and competence in teaching science as well as students enjoying learning science (Hackling & Prain, 2005). The 5E model being an activity based model of teaching and learning science it has the potential to develop 21st century skills such as adaptability, complex communications skills, non-routine problem solving, self-management/ self-development and system thinking (Bybee, 2009, 2010; NRC, 2006).

A unit of work of twelve lessons based on the 5E instructional model is developed for this study by the lead researcher and it is further refined with science teachers for suiting to school curriculum and implementation in classroom situations. Table 1 outlines a unit at a glance of final intervention unit of lessons and sequences.

1.2 Objectives and Purpose

1. Identify high school students' levels of prior knowledge related to the need and environmental issues related to Nuclear Power plants and provide with an authenticity and ownership with knowledge base (science behind this issue)
2. Identify and map out formal and informal reasoning patterns and intention for actions regarding Nuclear Power Plants by providing scenarios for them to discuss and make decisions and actions;
3. Suggest the links between informed knowledge, formal and informal reasoning patters, intention for actions and decision making.

2. Rationale and Research Questions

The aim is to provide a strong knowledge base regarding the issue of Nuclear Power plants in India and test how it influences their beliefs and further their opinion in Public Decision Making. The study centred on two primary research questions

- How does the 5E instructional model based unit of intervention enhance beliefs about the issue of Nuclear Power plants in India?
- Identifying links and influence of knowledge base in making decisions regarding Environmental issues of Nuclear Power Plants.

3. Methods

The questionnaire used was based on theory of reasoned action (Ajzen & Fishbein, 1980).The structured intervention lessons used the 5E instructional model as a framework. The data analysed qualitatively and quantitatively, and the qualitative data were coded into categories based on responses. These responses to beliefs, understanding and intentions were analysed to show their inter-relationships using the Structural Equation Model (SEM).

This study is conducted in four steps in sequence to suit methodology used and the details are as follows

Step1. Professional development for participating on the five E instructional model
Step2. Administering pre-test questionnaire.Step3. Intervention lessons are for two weeks. Intervention is set to identify beliefs and prior knowledge regarding Nuclear power Plants
Step4. Administering post-test questionnaire two months after the intervention to identify changes in belief.

3.1 Population

The sample used for this study is a group of 120 students of class IX from different(State, CBSE,ICSE) syllabus and as well as govt., private and residential setup. These children are selected as they are in their last yea of schooling and future decision makers.

3.2 Intervention Programme

Table1 given below illustrates the intervention programme based on the 5E Instructional model on "need of nuclear power plants in India" .The programme is divided into 12 lessons covering all 5 phases of the 5E.

In the engage phase, the basic beliefs about the structure o an atom and basic beliefs about the emission of radiations from the nucleus is included. In the explore phase, Nuclear reactions, generation of power from nuclear reactors and radiation management issues are discussed. Teachers took the lead role in the Explain phase and covered all aspects. Explain phase was done with the interactions of children as well as the intervention of teacher. Finally children came up with their group presentations in the Evaluation.

Table 1

Phase	Lesson	Description and Targets(B,U and ID)
Engage	1.What you believe about atoms and nucleus 2.What you believe and know about the structure and radiation emitted by NPP	Represent,discuss,flow charts, concept map etc which reflects the beliefs and understanding Making rough diagrams in an A3 sheet, comments, discussions, cartoons, poems to reflect the ideas.
Explore	3.Radiation emitted by NPPS	1.Identify and make connection 2.How radiation cause pollution
	4.Nuclear reactions	1.Discuss about historical events and side effects 2.Discuss about power projects, industrial development
	5. Nuclear Power plants	1.Identify the need 2.Discuss the advantages and disadvantages
	6. Nuclear radiation- cause and management	Discuss the variable available resources
Explain	7.Need for NPP	Discuss the advantages and disadvantages.
	8.facts and figures about NPPs and their operational details	Discuss the advantages and disadvantages

Elaborate	9. various group study	Developing a vision about NPP
	10. group discussion	Finding solutions and possible actions
	11.Group presentations	Presenting different outcomes and intentions for actions
Evaluate	12. Final class presentation	Generating an opinion based on discussions and deliberations

4. Data Collection and Analysis

The test and survey were coded to ensure teacher confidentiality and pre- and post-tests were matched by coded numbers. The questionnaire was standardised using t-test. These data were scanned and uploaded into an Excel data file for processing. The statistical package used in analyzing the data were box plot,mean,ANOVA,ANCOVA. Only completed data from students taking both the pre- and post-test/surveys were used in the analysis (n=120). Changes in pre- and post-test scores were analyzed using t-test, box plot,mean,ANOVA,ANCOVA and analysis of covariance. Relationships between test scores and teacher independent and school variables were analyzed using descriptive statistics, t-test, cross tab and correlation analyses.

4.1 Data analysis

The test and survey were coded to ensure teacher confidentiality and pre- and post-tests were matched by coded numbers. The questionnaire was standardised using t-test. These data were scanned and uploaded into an Excel data file for processing. The statistical package used in analyzing the data were box plot,mean,ANOVA,ANCOVA. Only completed data from students taking both the pre- and post-test/surveys were used in the analysis (n=120). Changes in pre- and post-test scores were analyzed using t-test, box plot, mean,ANOVA,ANCOVA and analysis of covariance. Relationships between test scores and teacher independent and school variables were analyzed using descriptive statistics, t-test, cross tab and correlation analyses. Also used Structural Equation Model (SEM) to identify Beliefs, understanding and intention relationship

Table 2 and Table 3 represent the data analysis of experimental and control group(N=120) regarding the overall knowledge in pre-test and post- test. Most of the students were having misconceptions about Nuclear Power Plants like “ it is a bomb”, “ it will surely explode” etc. before the intervention. Also most of the children were not having the minimum scientific knowledge about it. The “t” value obtained here is 13.85 and this is significant at 0.01 level. This shows that the level of knowledge of children in the experimental group has considerably changed during the intervention programme.

Table 2.Descriptive statistics for overall knowledge

	Pre test		Post test	
	Experimental	Control	Experimental	Control
Mean	66.3	70.2	87.7	67.3
Median	66.0	70.5	88.0	67.0
Mode	66.0	70.0	72.0	67.0
SD	6.7	6.4	16.2	6.4
Quartile deviation	2.5	4.8	12.4	3.0
Skewness	0.14	-0.15	-0.06	0.15
Kurtosis	0.16	0.37	0.29	0.21

Table 3 Unadjusted and adjusted mean scores at pre and post test achievement for overall knowledge

Group	N	Mx	My	My.x	t
Experimental	120	66.3	87.7	88.4	13.85**
Control	120	70.2	67.3	66.6	
Total	240	68.2	77.5	77.5	

**: - Significant at 0.01 level x : Pre test y : Post test y.x : Adjusted post

Table4 showing the comparison in the percentage increase in the belief score based on the type of institution they study.Out of 120 studnts, 40 each were in CBSE,ICSE and state run schools. 40 students of CBSE got a mean score of 23.2 and that of ICSE (40), the score is 18.0. The score of state run schools is very low, only 2.3. During the intervention, students from CBSE and ICSE students raised questions like 1." if we generate power from NPP, will it be cheap?" 2."Why people say that Nuclear Power is dangerous?" Students from state run schools asked a serious question-" why it is said that power from Nuclear Power Plant cause cancer?!!!."Too much misconceptions were there among the children of state run schools regarding this.

4.3 Effectiveness of FIVE E model knowledge base among the students of secondary school based on type of school

Table 4. Comparison of percentage increase in belief score based on type of school in experimental model

Type of school	Mean	SD	N	F	Sig.	Scheffe Multiple Comparisons		
						Pair	F'	p
CBSE (A)	23.2	20.6	40	19.54**	0.000	A &B	1.1	0.334
ICSE (B)	18.0	16.3	40			A & C	18**	0.000
State (C)	2.3	5.6	40			B & C	10.2**	0.000

**: - Significant at 0.01 level

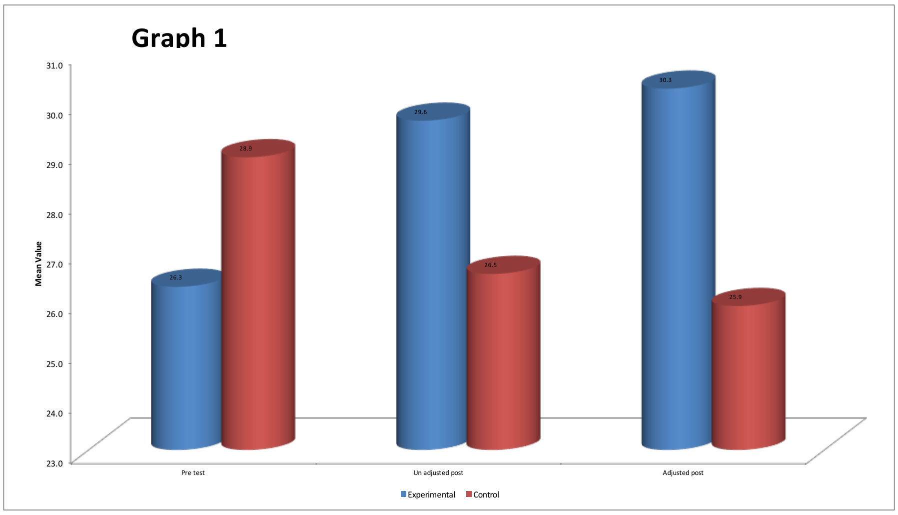
This shows that there is a difference in the beliefs of students studying in these schools about NPPs .The study is significant at 0.01 level.

4.4 Graphical Representations

The data were coded and for easy interpretation, graphs are plotted. General comparison is done for beliefs, understanding and overall knowledge of children. Each one is plotted separately. The results are very clear and easily understandable

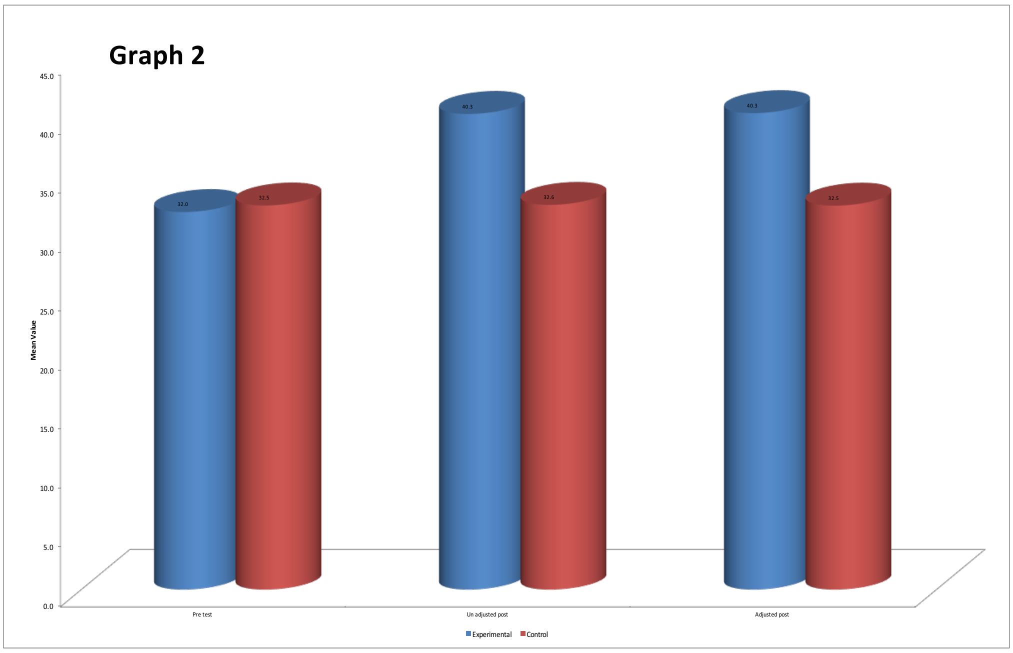
4.4.1 Unadjusted and adjusted mean scores at pre and post test achievement for beliefs

Graph 1 shows the mean score of pre-test and post- test achievements of children regarding their beliefs about the Nuclear Power plants. Students in the control group showed no considerable improvement after the post test, or rather changed their mind in a different way. The post test of the experimental group clearly shows a considerable change in their beliefs. The difference in the mean value is also large which clearly indicating the influence of the 5E model intervention



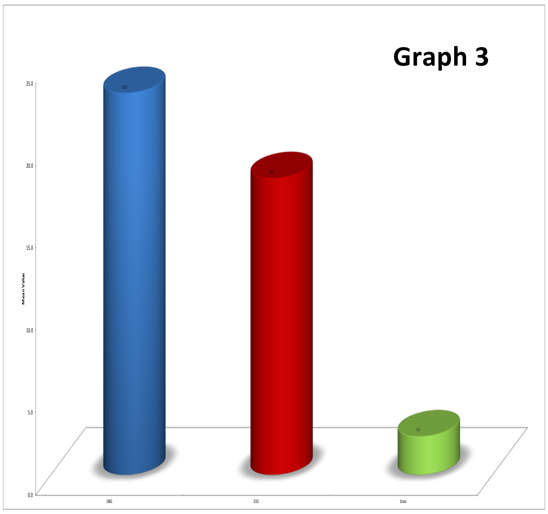
4.4.2 Unadjusted and adjusted mean scores at pre and post test achievement for intentions for action

Graph 2 shows the pre-test and post-test achievements(N=120) of children (mean score) regarding their intentions for action about Nuclear Power plants. The pre-test score of control and experimental groups are more or less same. But the post test score of the experimental group shows a significant difference, both in the un-adjusted (32.6-40.3) and in the adjusted(32.5-40.3).This clearly indicate that the 5E intervention had a significance in their intentions as well as their decisions in future. Before the intervention, children were not in a position to make a clear decision whether it is for the Nuclear Power Plant or against it. Now they are very clear in their intentions and scientifically confident in making a decision



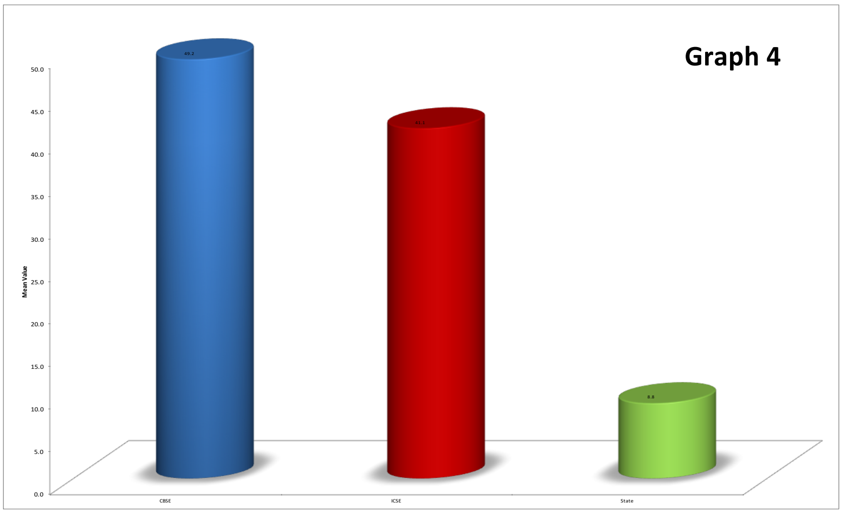
4.4.3 Ccomparison of percentage increase in belief score based on type of school in experimental model

Graph3 showing the change in percentage on the belief score compared to pre-test and post-test of experimental group(N=120). This is a very clear illustration of the fact that there is a difference between the curricula. The score is analysed depending on the type of institution they study and the results shows a maximum change for students studied in CBSE curriculum schools followed by ICSE curriculum schools. But the change is minimum in the case of state run schools. The general observation is that Children study in CBSE &ICSE schools in India are more receptive to new ideas and ready to accept challenges in life. During the intervention, children from CBSE and ICSE schools asked many questions and interacted nicely in the group. They enjoyed the programme and also contributed to make the programme, very live.



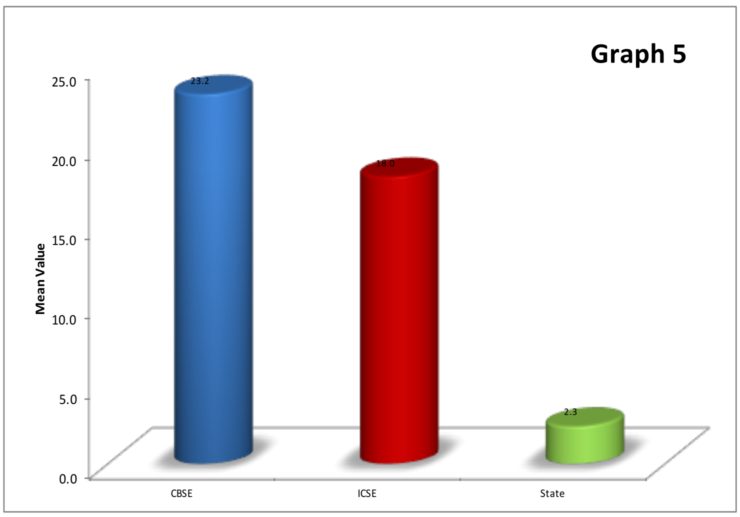
4.4.4 Ccomparison of percentage increase in overall knowledge score based on type of school in which they are studying.

Graph4 showing the percentage increase in overall knowledge of experimental group compared to pre-test and post-test(N=120). The score is analysed depending on the type of institution they study and the results shows a maximum change for CBSE curriculum schools followed by ICSE curriculum schools. The change is minimum in the case of state run schools again.



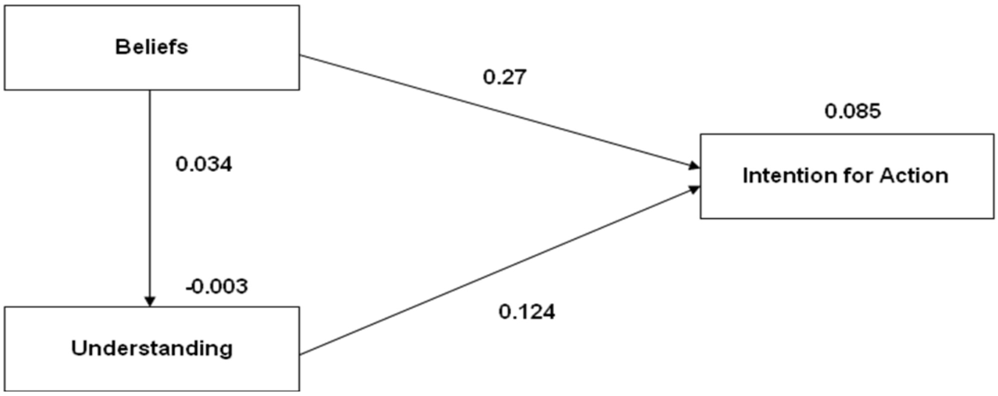
4.4.5 Effectiveness of five e model knowledge base on informed decision making in nuclear power plants in india, among the students of secondary school based on type of school

Graph 5 shows the percentage change in the score of children in the post-test depending upon the type of institution they study. The percentage change regarding informed decisions is maximum in the case of CBSE children and minimum in the case of State Schools children. There is a difference of about 16 to 20 between state run and CBSE type of schools, which clearly indicate that there exist a wide difference in the structural knowledge acquisition program between these type of institutions.



4.4.6 Structural equation model analysis of interdependence of beliefs and understanding, influence of beliefs and understanding on informed decisions.

Fig.1 shows the inter-dependence of Beliefs and understanding on Intentions for Action and influence of Beliefs on understanding. The structural equation model clearly shows the significance of beliefs and understanding on Intentions for Action



4.4.7 Teachers and Pre- Service teachers Comments

Three science teachers and two pre-service teachers with major science in science teaching were involved in this study. The 5E instructional model was formulated and implemented as a team with cooperative venture and was willingly undertaken in all its challenges for an effective completion. The cooperation and encouragement received from head of sciences and academic coordinators were very valuable at all stages of this intervention program.

The following were the final comments and observations from teachers and pre-service teachers. The quote given is almost the same repeated by other members also.
Teacher A:

"It was a great experience.They are concerned and committed about environment. It is normally a big issue to deal them during last two sessions on a Saturday; however, they were involved in formulating policies and researching ideas. Well unfortunately there won't be many such opportunity within classroom environment to engage that effectively in science, although most of them really hate science. I have taken them to science museums and this is more interesting and engaging for them…."

Pre- Service Teacher A:

"Everyone is involved; there were discussions, arguments, research, teaching and learning. They were very realistic and serious with their roles and committed in making decisions. 5E instructional model is a very good framework it is an inquiry based approach very engaging and providing lot of life skills to students. I enjoyed the teamwork and gave me more confidence and competence to teach."

Teachers and pre-service teachers played vital role in the success of this intervention and their comments concur with evidences from classroom and from questionnaire data. These interventions could lead to the following ideal scenario:

The ideal scenario describes students' beliefs, understandings and commitments to take actions that would enable individuals and communities regarding the use of Nuclear Power Plants in India.

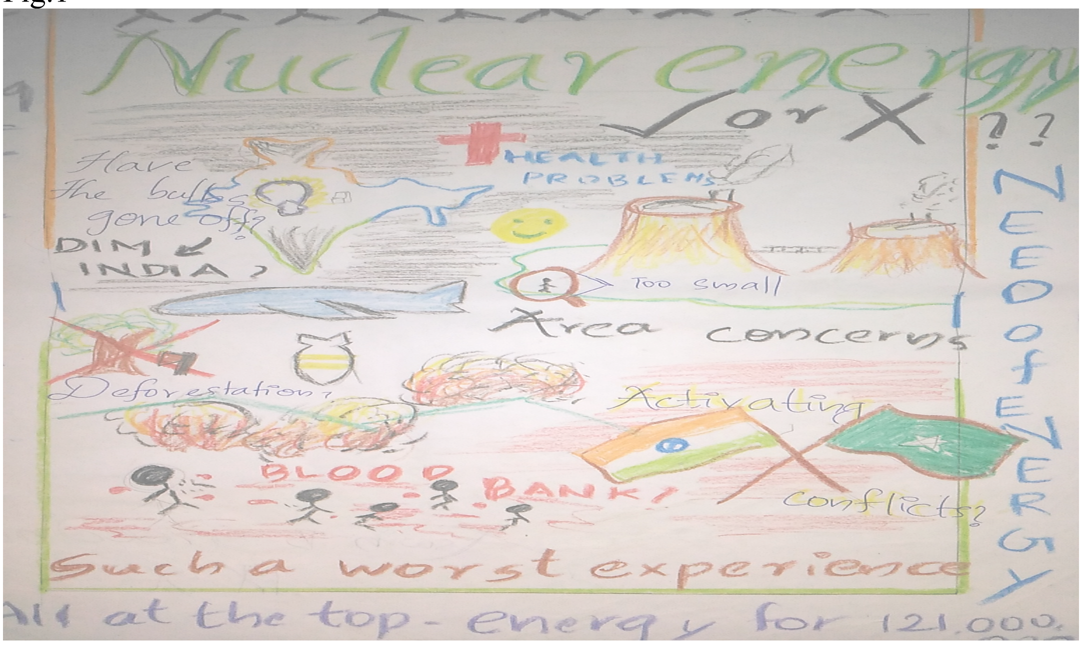
- Beliefs: the NPPs are to be handled carefully meeting all safety standards. It is not a bomb.
- Understandings: know that the NPPS may cause serious danger to society and at the same time capable of generating power at a very high rate.
- Commitment to take actions: students are now in a position to take a decision as part of National Policy making whether we need the NPPs or not. They will not depend on the opinion of others

Classroom teaching of science should encourage experience of issues related to environment in terms of decision making. This will provide opportunity for students' to engage real world decision making to issues such as energy use (Tsurusaki, etal., 2012). Decision making and formulating a policy documents based on classroom deliberations can empower students' in societal commitments and social justice (Dimik, 2012). These processes connect to the real use of science in daily life and probe engagement in science (Feinstein, 2010). Most of the teaching and learning science in classroom is disconnected o real world and become more formal and textual. In this circumstances promoting responsible socioscientific decision making though contextually teaching about science can influence responsible actions by future citizens (Herman, 2014).

5. Summary & Findings

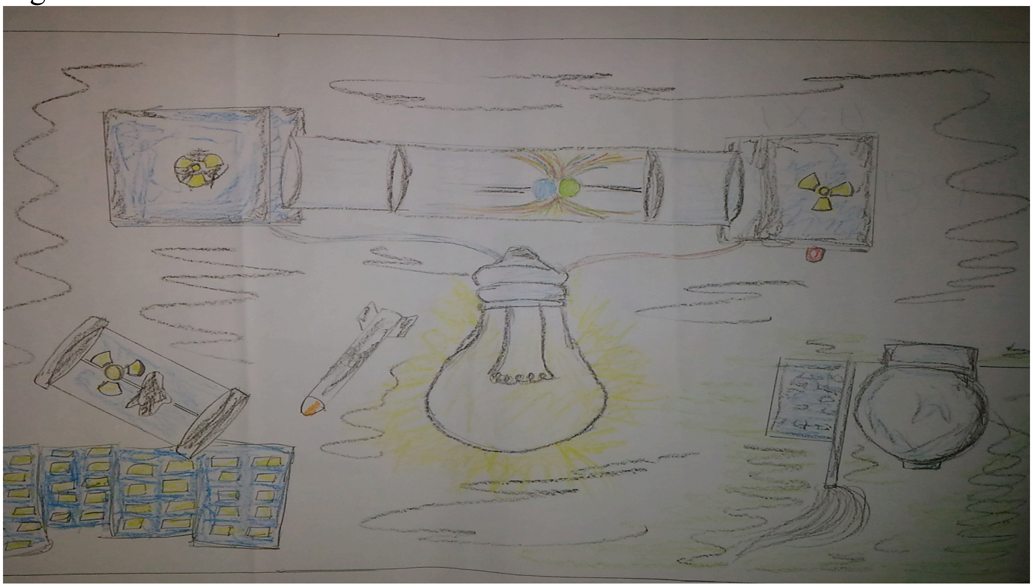
1. Before the intervention, children were having lot of ideas which are sometimes superstitions/unclear etc. One of the sample given below(Fig.1) explains well about the confused mind of children about the Nuclear Power plants and Energy production from Nuclear Power Plants.

Fig.1



2. After the intervention, the response was different, (Given in Fig.2)many children withdrew their idea of “a bomb “about Nuclear Power Plants and came up with more scientific reasons with logical background. Now they are able to derive conclusions of their own in a definite form.

Fig.2



3. After analysing the data, it is clear that unadjusted and adjusted mean scores at pre and post test achievement for overall knowledge of children studying in high schools, show a significant change in the knowledge level before and after the intervention.

2. Comparison of pre- test and post test on beliefs about Nuclear Power Plants among high school children, shows a significant & relevant change
3. Comparison of pre- test and post test on understanding about Nuclear Power Plants among high school children, shows a significant & relevant change .
4. Comparison of pre- test and post test on informed decisions about Nuclear Power Plants among high school children, shows a significant & relevant change .
5. There is a significant influence of beliefs and understanding about Nuclear Power Plants among high school children, on the decisions of children which is evident from the SEM and also there is a clear influence of Beliefs on understanding of children about Nuclear Power Plants

Based on these, the following conclusions have been derived

- **Overall findings indicate that before the intervention, future citizens’ believe and understand that Nuclear Power plants are harmful to the society and at the same time, needed for the economic development of the country and had misconceptions about the safety of the Nuclear Power Plants.**
- **Study showed a shift in their position after the intervention. The data analysis using SEM showed that there is considerable change in their beliefs, understandings and intentions before and after the intervention and the changes are not unique in all cases.**

- **These differences were depended on the type of institutions (State, central government and private schools).**

A 5E instructional model unit of work based on a real world socioscientific issue like the need of NPPs will provide students with skills such as justification of claims based on evidences. They would weigh credibility of claims based on evidences and will use their science knowledge in justifications (Sandoval & Cam, 2010). Overall engagement in such units can provide students an ability to cultivate knowledge and skills needed to participate in scientific argumentation and evidence based informed decision making (Sampson, Grooms & Walker, 2010). Nuclear Power Plants being a complex scientific issue student' confident belief and understanding of science behind this issue affirm the utility of knowledge in framing polices and evidence based decision making (Manz, 2012). The real gap identified in this study is that normal school curriculum has no place in engaging science in real world. Pre-service teachers are also not getting an opportunity to organise an inquiry based instructional sequence to teach in school filed placements (Gunckel, 2013). Use of an instructional model like the 5E instructional model by teachers and pre-service teachers can change classroom environment and provide students' to become scientifically literate citizens to make informed decisions regarding their health, wellbeing and environment (Gunckel, 2011). Bridging this gap needs a deliberate effort from all angles like school curriculum, teacher preparations and overall education policies. Simple thing to do is make connection to everyday life in communicating science fruitfully and provide opportunity for evidence based decision making in classrooms (Nibert, Marsch & Treagust, 2012).

Scientific literacy can easily be integrated in secondary school children through 5E model lesson sequencing and this may lead to a generation, scientifically aware of policy issues and there by a stronger democracy.

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