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Socio-Scientific Issues in Science Education Bridging the gap between concepts, actions and ethics

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Abstract

In modern educational settings, fostering conceptual understanding in science holds a central role in providing students with the vital knowledge and skills essential for navigating the intricacies of the natural world. With the rising scientific discoveries and the way they are impacting the society the Socio-Scientific issues are on the rise. This research aims to explore the conceptual understanding of Socio-Scientific issues among secondary students, delineating the levels of understanding and scrutinizing variations based on gender and geographical areas. This is empirical research conducted through survey method, with the researcher developed and validated Conceptual Understanding Test of Socio-Scientific Issue (CUT-SSI) in Science. The data was collected from the sample of 205 students selected through simple random sampling technique. The outcomes of the study revealed that a notable 40% of students had a low level, followed by 28.29% at a medium level and 31.71% at a high level of conceptual understanding of socio scientific issues in science. Analyses based on gender and geographical factors reveal comparable low levels of understanding among boys and girls, as well as between students from rural and urban areas. Though no significant gender and area difference was observed.

Key words: Conceptual Understanding, Socio-Scientific Issues, Science Education, pedagogy

Introduction

Science education is an important component of modern pedagogy, seeking to provide students with the knowledge and skills needed to appreciate and navigate the complexities of natural world. The view of science as practice is suggested by numerous cognitive and developmental psychologists who have studied 'situated cognition' (Brown, Collins & Dugid, 1989) and others and basically focusses on activity studies. The development of conceptual knowledge, which goes beyond lowest level of taxonomy i.e. memorizing (Bloom et al., 1956) and allows pupils to grasp the basic concepts driving scientific events, enables learners to grasp the underlying principles steering Socio-Scientific phenomena. It goes beyond simply learning facts and figures, emphasizing understanding of fundamental ideas and the capacity to apply them to a variety of circumstances. A solid conceptual knowledge foundation not only promotes Socio-Scientific literacy but also cultivates critical thinking abilities, allowing individuals to engage with the scientific process and make informed judgments in an increasingly complicated world.

As educators and policymakers seek to enhance the effectiveness of science

education, it becomes imperative to identify and analyze the variables that impact students' conceptual understanding. Socio-Scientific issues are societal problems that involve an interaction of scientific knowledge with complex social and cultural considerations. These issues go beyond the well-established scientific knowledge and principles and entails complex situations that may involve science in the making (Latur, 1987) so that the science can be developed for the benefit of the society in particular and humanity at large. The most recent example could be COIVD-19 pandemic which changed not only the societal perspective towards how we live but also annulled many established scientific processes like vaccine development.

The very realization of science as the reflection of culture and philosophy changes the perspective of how a teacher should approach the teaching of science in the classroom. Thus, with this rational an effort is made to study the Socio-Scientific issues based instruction and its effect on some of the important aspects of learning including conceptual understanding and argumentation. The study focuses on complex aspects impacting students' knowledge of socio scientific concepts,

filling a major vacuum in existing work and giving critical insights for educators and policymakers. The study aims to keep its findings consistent with the requirement of cultivating good conceptual understanding in science, which is critical for informed decision-making in societies that are becoming increasingly reliant on scientific knowledge. Finally, the research seeks to revolutionize scientific education practices by providing actionable insights that can improve quality, inclusivity, and effectiveness, thereby benefiting students, educators, and society as a whole.

With this rational and background, the objectives of the study were defined as under.

Objectives

1. To determine the level of conceptual understanding of socio scientific issues in science among the secondary students.
2. To determine the level of conceptual understanding of socio scientific issues in science among the secondary students with respect to gender.
3. To determine the level of conceptual understanding of socio scientific issues in science among the secondary students with respect to area.

Research Area

The quest for knowledge has been a constant and driving force in the evolution of humankind since ancient times. It is this fervor for discovery and comprehension that forms the cornerstone of any research. (Pawar, Purushottam & Daniel et.al. 2023).

Since the present study is investigating socio scientific issue based conceptual understanding among secondary students so it addresses the research areas of Teaching of Science and Psychological Testing.

The study is quantitative research since the researcher is using data in the form of numbers to test the hypothesis.

Hypotheses of the study

Ho₁ There is no significant difference between the mean score of conceptual understanding of socio scientific issues in science obtained by boy and girl students.

Ho₂ There is no significant difference between the mean score of conceptual understanding of socio scientific issues in science obtained by students from rural and urban area.

Limitation of the study

- The limitation of sampling technique and the tool remains the limitation of the study.

Delimitation of the study

- The study is delimited to students of standard 10 of Gandhinagar District only.

Operationalization of the key-words

- **Conceptual Understanding**

Theoretical Definition: Conceptual understanding refers to a profound comprehension of fundamental principles and underlying concepts within a specific domain of knowledge, enabling individuals to connect, apply, and transfer their knowledge to varied contexts. (Driver, Guesne, & Tiberghien, 1985).

Conceptual understanding involves a deep awareness and insight into the organizational structure of knowledge, allowing individuals to go beyond surface-level information and engage in meaningful problem-solving and critical thinking (Vosniadou, S. 2008).

Operational Definition: In present study, scores obtain by students of standard-10 on researcher developed Conceptual Understanding Test of Socio-Scientific Issues (CUT-SSI) was considered as a conceptual understanding in Science of the

Students. The test was developed to evaluate the ability of the students to grasp and integrate complex societal issues and their capability to translate in scientific problems and probable scientific discoveries and solutions.

- **Socio Scientific Issues**

Theoretical Definition: Socio-Scientific Issues (SSI) refer to complex and multifaceted challenges at the intersection of science, society, and ethics. These issues involve scientific content but also encompass broader societal, cultural, economic, and ethical considerations. These issues emphasize the interconnection between scientific knowledge and its societal implications (Sadler, Barab, & Scott, 2007). The recognition of SSI underscores the importance of engaging learners in critical thinking and decision-making processes related to real-world problems that have scientific dimensions (Zeidler & Nichols, 2009).

Operational Definition: For the present study, Socio-Scientific issues refers to selected concepts in secondary school science textbook like sustainable management of natural resources, heredity and evaluation related concepts through

which the Socio-Scientific issues can be addressed.

Variables of the Study

Table 1: Variables of the Study

No.	Variable	Type		Measurement
1	Independent Variable	Gender	Boy	Intervention
			Girl	
2	Independent Variable	Area	Rural	
			Urban	
3	Dependent Variable	Conceptual Understanding of Socio-Scientific issues		Conceptual Understanding Test of Socio-Scientific issues (CUT-SSI)
4	Control Variable	Standard 10, Socio-Scientific Issues		

Population and Sample

Population refers to the set or group of all the units on which the findings of the research are to be applied. (Shukla, Satish 2020)

Sample is selected in many researches to collect the data in order to realize the research objectives. Various factors are to be kept in mind while deciding the sample size and technique of selecting the sample. The students of standard-10th of the all the secondary schools in Gandhinagar District was defined as the population of the present study. The sample was selected using simple

random sampling technique. One secondary school from urban area and one from rural area was selected by Lottery Method. All the students of standard-10th studying in selected schools were selected as the sample using cluster sampling technique. Thus, selection of school was by Simple Random Technique and selection of students was by cluster sample method. The sample included a total of 205 students of standard-10th out of which 97 were from rural area and 108 from the urban area. The details of sample is shown in Table 2.

Table 2: Sample Distribution across the variables

	Rural	Urban	Total
Boy	48	49	97
Girl	49	59	108
Total	97	108	205

Research Methodology

Research is the engine driving progress and knowledge. (Kumar A., Geetha M. & Ranjan R., 2023). The Descriptive Survey Method was used to collect the data for the present study.

Tool: Conceptual Understanding Test of Socio-Scientific issues (CUT-SSI)

A careful, methodical process was used to create the Conceptual Understanding Test of Socio-Scientific Issues (CUT-SSI). Initially in-depth examination of conceptual comprehension in science that relates to the Socio-Scientific issues were identified from standard 10 text book. Two topics Evaluation & Heredity and Sustainable Management of Natural Resources were identified for the CUT-SSI. The test was prepared keeping in view the Socio-Scientific relations these two topics within the daily life and surroundings. The primary test version that was created for validation consisted of 71 questions which were then put to piloting, expert validation and feedback. Item effectiveness was assessed by item analysis, resulting in a final, well-

validated Conceptual Understanding Test in Science suited for use in the research study. The final tool consisted of 50 questions divided into two types of questions viz. Multiple-Choice Question and True - False.

Data Collection & Analysis

The permission of the principals of selected schools was sought. After obtaining the due permission a rapport was developed with the sample students. The test was administered to the students and the data collected. The duration of the time allotted to them was 60 minutes. The data so collected for CUT-SSI was put to analysis using Excel Program of the Microsoft Office. The data was classified as per objectives and hypotheses with the help of filter. To determine the level of conceptual understanding of Socio-Scientific issues P33 and P67 was calculated. To test the null-hypotheses, “t”-test was applied.

Level of Conceptual Understanding about Socio-Scientific Issues

Table 3 shows that overall Conceptual Understanding about socio scientific issues of the students in science subject. It shows

that 40% of the students have low understanding and 31.71% have high understanding, 28.29% have medium understanding of the issues.

Table: 3: Level of Conceptual Understanding about socio scientific issues in Science

Level	Norms		No. of Students	%
Low	Min-P33	38-41	82	40.00
Medium	P33-P67	42-45	58	28.29
High	P67-Max	46-50	65	31.71
Total			205	100 %

Level of Conceptual Understanding about Socio-Scientific Issues in context of gender

Table 4 shows that overall Conceptual Understanding about socio scientific issues of the students in science subject with reference to the gender. It shows that 40.21

% of the boy students and 39.21% of the girl students have low understanding, 27.84% of boy students and 28.70% of girl students have medium understanding and 31.96% boy students and 31.48% girl students have high understanding of the issues.

Table 4: Level of Conceptual Understanding about socio scientific issues in Science in context of Gender

Level	Norms		Boy		Girl	
			No. of Students	%	No. of Students	%
Low	Min-P33	38-41	39	40.21	43	39.81
Medium	P33-P67	42-45	27	27.84	31	28.70
High	P67-Max	46-50	31	31.96	34	31.48
Total			97	100.00	108	100.00

Level of Conceptual Understanding about Socio-Scientific Issues in context of area

Table 5 shows that overall Conceptual Understanding about socio scientific issues of the students in science subject with

reference to the area. It shows that 46.39 % of the rural students and 34.26% of the urban students have low understanding, 24% of rural students and 33% of urban students have medium understanding and 27.84%

rural students 38% urban students have high understanding of the issues. The same is shown graphically also in Figure - 1.

Table 5: Level of Conceptual Understanding about socio scientific issues in Science in context of Area

Level	Norms		Rural		Urban	
			No. of Students	%	No. of Students	%
Low	Min-P33	38-41	45	46.39	37	34.26
Medium	P33-P67	42-45	25	25.77	33	30.56
High	P67-Max	46-50	27	27.84	38	35.19
Total			97	100.00	108	100.00

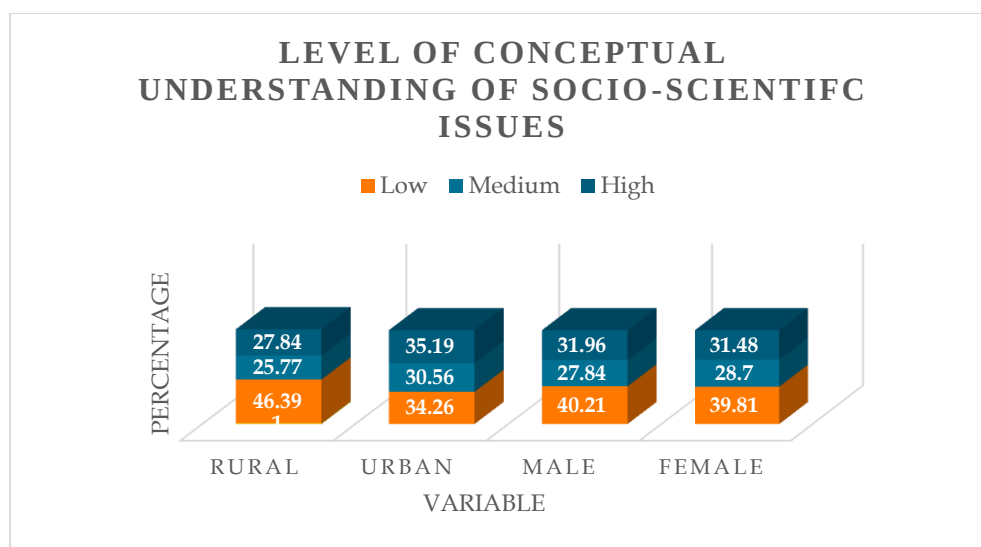


Figure 1: Level of Conceptual Understanding about socio scientific issues

Hypothesis Testing

The two null hypothesis were tested using the t test. The inferential data for the mean, standard deviation, Standard Error of Deviation (S.E.D) and t values are given in

Table 6. The table shows that the Critical Ratio (C.R.) for the boy and girl students is 0.65 and for the rural and students is 1.71. Both the values are less than the table values therefore they are not significant. Thus both

the hypothesis are accepted and there is no difference between the conceptual understanding of Socio-Scientific issues of

the a) boy and girl students b) rural and urban students.

Table 6: Inferential values for the Hypotheses Testing

Ho	Group	N	M	SD	S.E.D.	C.R.	Remarks
Ho1	Boy	97	43.32	3.84	0.52	0.65	Not Significant
	Girl	108	42.98	3.53			
Ho2	Rural	97	42.68	3.65	0.51	1.71	Not Significant
	Urban	108	43.56	3.67			

Findings

The study delves into some important aspect of science education and seeks to study the sociological and ethical impact of the science education in the secondary classrooms of science subject. The findings of the study are:

- 1) Most students, accounting for 40%, fall within the category of low conceptual understanding about socio scientific issues in science. Approximately 28.29% of students demonstrate a medium level of conceptual understanding about socio scientific issues in science, while a noteworthy 31.71% exhibit a high level of conceptual understanding in this subject.
- 2) When considering gender differences, among boys, 40.21% show a low conceptual understanding about socio

scientific issues in science, while 27.84% and 31.96% exhibit medium and high conceptual understanding about socio scientific issues in science, respectively. Conversely, girls display a similar distribution, with 39.81% in the low conceptual understanding about socio scientific issues in science category, 28.70% in the medium conceptual understanding about socio scientific issues in science category, and 31.48% in the high conceptual understanding about socio scientific issues in science category.

- 3) Examining the influence of residential areas on students' conceptual understanding about socio scientific issues in science, 46.39% of students in rural areas exhibit a low level of understanding about socio scientific

issues, while 25.77% have a medium level and 27.84% demonstrate a high level. In urban areas, 34.26% show a low conceptual understanding about socio scientific issues, 30.56% have a medium conceptual understanding about socio scientific issues, and 35.19% demonstrate a high conceptual understanding about socio scientific issues in science.

- 4) Regarding the conceptual understanding about socio scientific issues of science, there is parity between boys and girls, with no significant difference in their levels of comprehension.
- 5) Concerning the conceptual understanding about socio scientific issues of science, students from rural and urban areas exhibit an equal level of proficiency, indicating comparable levels of comprehension across these diverse residential contexts.

Educational Implication

The present study has several educational implications that can guide interventions and improvements in science education:

1. Targeted Support for Low Conceptual Understanding

The identification of a considerable percentage of students (40%) with

insufficient conceptual knowledge highlights the need for targeted support and interventions. Educators should create specific curricula to address the fundamental topics, ensuring that pupils get a solid scientific basis.

2. Gender-Inclusive Science Education Strategies

According to the study, there is no significant difference in conceptual understanding about socio scientific issues between boys and girls. Even then when we see the levels a good 39% boys and 43% girls have low levels of conceptual understanding about Socio-Scientific issues. This discovery promotes the need for creation of gender-inclusive science teaching initiatives where in science education has to be looked beyond the perspectives of teaching science concepts to integrating the sociological and ethical perspectives around which the science concepts are built. Teachers and curriculum authors can concentrate their efforts on building an integrated and inclusive learning environment that meets the different needs of all students, regardless of gender with an integrations of concepts as whole and breaking the silos of subject boundaries.

3. Addressing Rural-Urban Disparities:

The gap in conceptual understanding about socio scientific issues between rural and urban students is not significant but it does emphasize the need of addressing geographical variations where in 45% of rural students and 37% of urban students fall under the category of low levels of conceptual understanding about Socio-Scientific issues.. Policymakers and educators should think about customizing scientific education programs to the unique difficulties and opportunities that exist in both rural and urban contexts. Closing this gap will lead to more fair educational outcomes which are not only comprehensive in nature but are able to take in account the outcomes from affective and psychomotor domains.

4. Promoting Science Education as content, process and outcome

This research highlights the effectiveness of existing educational practices in preserving gender and area equity. Educators and governments should continue to work to make science education accessible and helpful to all students, regardless of gender and area. But an important aspect that they should consider is that science should be addressed in classrooms not only in terms of content only but rather as a process which

emerges from our daily societal needs and demand not in isolation but as culmination from knowledge as a whole.

Conclusion

In conclusion, this study focused on the vital function of conceptual understanding about socio scientific issues in science education, highlighting its importance in developing students' scientific literacy and critical thinking skills. The investigation of many elements influencing conceptual understanding, ranging from instructional approaches to socioeconomic backgrounds, aims to provide significant insights for educators and policymakers alike. The study, which was conducted among standard-10 pupils in Gandhinagar District, intended to test and examine their conceptual comprehension of science while accounting for gender and region characteristics.

The data revealed that a large majority of pupils (40.00%) had a poor degree of conceptual comprehension, 28.29% had a medium level, and 31.71% had a high level. Further examination based on gender and location revealed similar levels of conceptual knowledge across boys and girls, as well as pupils from rural and urban locations. The research objectives, which

included the investigation of conceptual comprehension, the determination of levels, and the investigation of gender and area-based variances, were successfully met. There were no significant variations in conceptual understanding about socio scientific issues between boys and girls, or between students from rural and urban settings, according to null hypotheses testing. It is critical to acknowledge limitations such as the sample technique and reliance on self-reported data. The study's focus on standard-10 children in Gandhinagar District limits its applicability to other communities. The survey approach was used to collect data, which was guided by the educational psychology study area. This study contributes significantly to the area by offering insights into the intricate dynamics of conceptual comprehension in science education.

It lays the groundwork for evidence-based teaching methodologies and has implications for educational practitioners, curriculum writers, and legislators, pointing to ways to improve scientific education practices in order to better meet the different needs of children. When the issues in the society are addressed through the Socio-Scientific pedagogy in the classrooms definitely they

will take a big move to bridge the gap between science education, ethics and action.

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