ISSN 0036-679X (print)
0972-5061 (online)

School Science

A Quarterly Journal of **SCIENCE EDUCATION**

Vol. 55 No. 4 **December 2017**

Picture shows Audio-video material dissemination in Government Girls Senior Secondary School, Vasant Kunj, New Delhi

Editorial Advisory Board

* This issue is printed in August 2023

ISSN 0036-679X (print)
0972-5061 (online)

Vol. 55 No. 4 December 2017

Contents

EDITORIAL

This issue of School Science includes four research papers and two articles from different domains of science education for our readers.

In the research paper entitled 'Construction and Pilot Test of an Instrument to Measure the Gaps in Teaching-learning of Science at Middle Stage in Select Tribal Dominated Rural Schools of Chhattisgarh, India,' the research team could evolve an instrument for measuring the learning gaps for designing strategies for improving teaching-learning process in science for middle stage learners in rural schools.

The research findings of the study 'Awareness of Socio-Scientific Issues among the Higher Secondary Students' give the status of awareness of higher secondary students about socio-scientific issues. It also provides information about the influence of gender, board, academic discipline on the awareness of these issues; however, the study reveals that it is not influenced by students' locality. The research study 'Effectiveness of Audio-Video Material in Teaching-learning Process at Secondary Stage' provides the status of the types of audio-video teaching materials available in the schools, frequency of their usage in schools, steps taken by the school in promoting the use of audio-video resources and the effectiveness of these resources in the teaching-learning process. The information from students, teachers, and administration was explicated using questionnaires. Findings reveal that the teachers hardly used audio-video materials due to a lack of infrastructure or awareness regarding the advantages of audio-visual learning. Therefore, it may have implications for policymakers for improving ICT infrastructure.

In the paper 'Implementing a Large-scale Assessment Survey to Understand the Learning Levels for Policy Implications and to Improve Teaching-learning,' the author has elaborated the initiatives of the Ministry of Education (MoE) to conduct the National Achievement Survey (NAS) India in 2017 with an objective to understand the learning levels of the students in Grades 3, 5 and 8, which may have policy suggestions for improving teaching-learning. The survey findings helped to guide education policy and enabled differential planning at the district level to enhance classroom level teaching-learning.

The article 'Utilisation of Innovative Technology towards a Human-Centred Future Society' gives information about technological innovations vis-à-vis the economy and society. The article 'Climate Change: A Global Phenomena' draws readers' attention to the unprecedented changes in global climate resulting in serious implications on the survival of both human and animal species on earth.

In the paper "Effect on the Volume of Solvents After Dissolution of Solutes" the authors have made efforts to make readers understand with the simple concept of dissolving different solutes in different volume of solvent and the change in the volume of a solution.

The issue also has 'Science News' and 'Web Watch' for readers. We wish all readers a fruitful reading. Your kind suggestions are always welcome.

Form IV *(See Rule 8)*

School Science

1. Place of Publication	National Council of Educational Research and Training (NCERT), Sri Aurobindo Marg, New Delhi 110 016
2. Periodicity of Publication	Quarterly
3. Printer's Name	Manoj Sharma: M/s Chaar Dishayen Printers Pvt. Ltd. G-39 & 40, Sector, Noida (UP) 201301
(Whether citizen of India?)	Yes
(If foreigner, state the country of origin)	Not applicable
Address	
4. Publisher's Name	Anup Kumar Rajput
(Whether citizen of India?)	Yes
(If foreigner, state the country of origin)	Not applicable
Address	Professor and Head, Publication Division, NCERT, Sri Aurobindo Marg, New Delhi 110 016
5. Editor's Name	Sunita Farkya
(Whether citizen of India?)	Yes
(If foreigner, state the country of origin)	Not applicable
Address	Academic Editor, Department of Education in Science and Mathematics, NCERT New Delhi 110 016
6. Names and addresses of the individuals who own the newspaper and partner or shareholders holding more than one per cent of the total capital	National Council of Educational Research and Training, New Delhi *(An autonomous body of the Government of India in the Ministry of Human Resource Development)*

I, Anup Kumar Rajput, hereby declare that the particulars given above are true to the best of my knowledge and belief.

Publisher

CONSTRUCTION AND PILOT TEST OF AN INSTRUMENT TO MEASURE THE GAPS IN TEACHING-LEARNING OF SCIENCE AT MIDDLE STAGE IN SELECT TRIBAL DOMINATED RURAL SCHOOLS OF CHHATTISGARH, INDIA

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The present study intends to develop tools to find out the gaps in science teaching and learning in select schools of scheduled tribes-dominated districts of Chhattisgarh. The tools development was completed in four phases following a modified Plomp model. In the preliminary investigation phase, research team members visited the schools of Chhattisgarh to analyse and determine the need. In the design phase, with the help of experts' opinion, the design of tools was finalised. In the construction phase, the development of four tools and their review with the panel of experts was carried out. These tools were; Tools for assessing attainment to leaner in leaning science for Classes VI, VII and VIII (TALS); a tool for attitude of learners in learning science (TATLS), Classroom Observation Schedule (COS), School Observation Schedule (SOS). Draft tool for Performance Indicators for Teachers (TPIT) developed by NCERT was administered in the study with minor modifications. In the time final, test evaluation and revision phase four, after the pilot test of tools in four schools of Raipur, Chhattisgarh, and data analysis, four tools were finalised again by a panel of experts. However, for the tool for assessing learners' attainment in learning science (TALS) for Classes VI, VII and VIII after applying in SPSS version 16 and Kuder Richardson formula 20, (KR 20), individual item analysis was suggested in the study.

Keywords: Instrument, Teaching-learning of Science, Tribal schools.

1. Introduction

In India, science learning in school education has been envisioned as a significant paradigm shift in learning strategies as recommended in National Curriculum Framework 2005. NCF 2005 emphasises learner-centred pedagogy rather than a teacher-centric approach. This major paradigm shift has necessitated bringing changes in curriculum transaction strategies for achieving the associated goals at the grassroots level (NCERT, 2006). Students' engagement in the process of learning is the most crucial expression to implement this change so as to follow this educational reform (NCERT, 2006). Thus, the science curriculum envisages 'learning by doing', connecting concepts with day-to-day life outside the school beyond the textbook (NFG Position Paper on Teaching of Science, 2006).

After independence, the education sector in India has expanded to a great extent but without any assurance of equity in educational opportunity or quality of education. Despite the Right to Education Act, 2009 (RTE) for providing equal opportunity, achievement of learning outcomes continued to remain poor for several children, primarily from disadvantaged groups. This may be due to various reasons, such as diversified social strata, rural and urban divides, lack of information due to geographical locations, etc. (CBPS, 2017). Tribal populations continue to have one of the lowest enrolments and retention rates as well as learning outcomes in the country, despite efforts for more than half a century of interventions for bringing improvement in their educational status (CBPS, 2017).

Quality teaching and learning, specifically in science, is crucial for developing scientific literacy in the young generation and improving economic productivity for sustainable development. The Indian school curriculum and policies have forged a remarkable level of consensus that science education is vital for all children attending schools. Hence, science is prescribed as a compulsory subject from elementary school onwards. "We can regard good science education as one that is true to the child, true to life and true to science" (NFG Position Paper on Teaching of Science; p. 2). Our vision towards improving the learning of science encompasses three factors: the learner (child), the environment — physical, biological, and social (life) in which the learner is embedded, and the object of learning (i.e., science in the present context) (NFG Position Paper on Teaching of Science; p. 2)

Even after almost ten years post-NCF 2005, the percolation of spirit and recommendations of the National Curriculum Framework at grassroot level was very slow. It may be due to cascade model of teacher training education programmes. Following the cascade model, it might have been diluted when it reached the end-users through various steps in the chain of the school system from national to state and finally to schools through the district, block, and clusters by Key Resource Persons. Thus, to meet the goals and objectives of science education as per the recommendations of NCF 2005, it is a prerequisite to assess the impartation of curriculum, as translated in the syllabus and further into textbooks and other teaching-learning material, through learners, classroom practices, and the learning environment.

To continuously bring the quality standard and due recognition to the current curriculum in science at the grassroots level, it is essential to get feedback from time to time in view of ensuring optimum learning experiences for learners and continuous improvement in quality of learning in science (NCERT, 2017). For assessing students' learning experiences and achievement of learning outcomes, all factors including learning environment in which the learner is embedded with the learning process, teachers' role as facilitator in teaching-learning process, learners' attitude towards Science learning and attainment of learning outcomes by them need to be taken into account. Thus, the objective of the study was to develop assessment tools to find out the gaps to get the inputs for continuous improvement in the quality of curricular material, and teaching-learning process and teacher education programmes.

The present paper includes a systematic development of assessment tools for data collection to assess implementation

of the National Curriculum Framework recommendations in learning of science in select rural schools of two scheduled tribe-dominated districts of Chhattisgarh state of India so that the baseline status of teaching and learning of science in the schools of scheduled tribes dominated districts of the state Chhattisgarh may be assessed, and the learning gaps may be identified, intervention may be planned and tried out, and a framework may be developed for in-service teacher education.

2. Methodology

2.1 Theoretical Framework

Many educational theories such as socio-cognitive learning, self-efficacy, experiential, reflective, and communities of practice theories have been considered in the present study. However, there is little mention of theoretical frameworks or orientations in the literature regarding science learning as recommended by the current curriculum, especially in tribal-dominated areas of India.

Since any instrument for such studies was not reported earlier for tribal-dominated rural schools of Chhattisgarh state, it is logical to construct tools for the same. For the appropriate measuring techniques for accurate data collection and arriving at correct and error-free conclusions for meeting out the objectives of the study, it is reasonable to construct an instrument using the commonalities with similar disciplines, or interacting disciplines such as Social Science and Mathematics. An underlying characteristic and assumption of the theories followed in this study is that learning involves social participation.

Due to the unavailability of suitable tools for accomplishing the study's objectives to assess science teaching-learning at the middle stage, the researchers' team ventured to construct the instrument afresh. An instrument was developed to establish a baseline of a student's conceptual learning in science and find gaps in the teaching-learning process and learning environment. Further, keeping in mind the definition of quality (NCERT-QMT, 2013), tools were also developed to assess other components of the teaching and learning process in the classroom and learning environment.

2.2 Research Procedure

Construction of tools for the measurement of teaching-learning of science at middle stage learners in tribal-dominated rural schools was carried out following modified Plomp model (Table 1):

Table 1

Research Procedure Phase-wise

Phase I	Phase II	Phase III	Phase IV
Preliminary Investigation • Material analysis	Design • Literature Survey • Setting-up a criteria for construction of instrument	Realisation and Construction • Development of an initial pool of items for tools	Test Evaluation and Revision • Pilot test and administration of assessment tools

• Student analysis • Competency analysis • Front end analysis	• Setting-up a criteria for development of items for construction of tools	• Review of the assessment tools by a panel of experts	• Analysis of the data • Finalisation of tools

In the first and second phases, besides a thorough literature review/survey, the research team performed extensive information retrieval by first, second, third, seventh, and eighth authors. This was followed by visits in schools of Chhattisgarh to observe the ground reality by second, fifth, and eighth authors regarding the implementation of recommendations of the present curriculum for assessment of which instrument was to be developed by all authors. In addition, all authors also consulted the literature on other assessment tools used in various survey researches for assessing the status of teaching and learning. In Phase III the second and eighth authors established the discussion forum to generate an initial pool of items by all the research team members for the development of tools to assess various aspects as per the preliminary investigations by analysis of material, student, competency and front end analysis followed by expert opinion.

2.3 Study Design

The present study focuses on design and construction of tools for exploring the status, needs, and attitude of science teachers and learners for improving the teaching and learning of science. Five assessment tools were finalised based on the different approaches adopted for data analysis, including triangulation of data, mixed-method approach to consider multiple viewpoints, perspectives, positions, and standpoints to improve teaching and learning of science in rural schools of scheduled tribes dominated districts of Chhattisgarh.

The research design utilised in this study consists of three distinct approaches: expert opinion, focus group discussion, and quantitative survey. The approaches are described as follows for different tools:

Table 2

Study design approach used for construction of the tools phase-wise

S.No.	Research Procedure	Study design (approach used)
1.	Phase I Preliminary Investigation	Literature survey, field visit, and analysis by the research team followed by focussed group discussion
2.	Phase II Design	expert opinion
3.	Phase III Realisation and construction	expert opinion, focus group discussion
4.	Phase IV Test Evaluation and Revision	focus group discussion, survey for field try-out

2.3.1 Phase I Preliminary Investigation

All the textual material, including primary and upper primary classes were obtained from SCERT, Chhattisgarh.

The research team visited the schools of Chhattisgarh to observe ground realities in the teaching and learning process for student and competency analysis. As a result, a blueprint for the development of tools was designed.

2.3.2 Phase II Design

2.3.2.1 Expert Opinions

Initially, expert opinion was sought for generating information about the determinants of effective science learning. A preliminary instrument as draft tools was presented to all expert participants. They were invited to identify important aspects that may assess the teachers, learners, and learning environment as well as relevant domains that could form sections or subsections of a questionnaire. Notes were taken from all the experts and compiled by the second and eighth authors for further inputs. Suggestions and comments were discussed, and with the consensus of the research team members, the domains for the development of different tools were finalised. Textbooks procured from SCERT, Raipur, Chhattisgarh were also consulted.

Data analysis was carried out following the content analysis method as suggested by Flick, 2002, with an aim to identify variations in perspectives. The third and eighth authors reviewed outcomes, comments, and domains, and all authors modified the preliminary draft questionnaire. A focus group session was planned with an agenda of "Exploring Needs of Students and Teachers for Improving Teaching and Learning of Science." It was followed by the development of items and draft tools.

2.3.3 Phase III Realisation and Construction

2.3.3.1 Focus Groups for Expert Validation of Draft Questionnaire

Both the focus group meetings were held during the 2015/16 academic year; first meeting at DESM, NCERT, New Delhi, followed by the second meeting at the SCERT, Raipur, Chhattisgarh.

In the second phase, expert validation of tool items was done by focus group review discussion of those items by a panel of experts at the national level by providing their comments. A set of a few semistructured triggering questions on any ambiguity, completeness, and clarity in understanding of the items and its relevance to teaching and learning of science were identified by the first, second, third, and eighth authors for each item to facilitate the group discussion and to assist future questionnaire development. The experts group reviewed all the tools, and necessary corrections were made in view of the following criteria:

1. Options given in multiple-choice questions should be appropriate.
2. Difficulty level of the items in the said tools must be in 25:50:25 for easy average and difficult types.
3. Items should assess learning outcome for various competencies in learners.

4. Items must be application-based, problem-solving, critical thinking, creative skills, and understanding.
5. Items from the whole syllabus must be included.
6. Language should be appropriate and easily understandable.
7. There should not be any ambiguity in the question stem or any of the multiple options.

All the tools were reviewed by subject experts from Chhattisgarh state, keeping in view the following points:

1. Contextualisation: The items were modified as per the local context
2. Cultural inputs
3. Language efficiency
4. Difficulty level in the context
5. Content cognition in the context

It was followed by another focus group meeting with a panel of state-level experts at SCERT, Raipur Chhattisgarh, to address contextual issues. A set of a number of criteria guiding the focus group meeting with a panel of state experts was identified by first, second, third, fourth, and eighth authors that included learners' language, culture, and natural phenomena in their surroundings for developing and fine-tuning the items in the assessment tools.

Based on comments received during the FGD for each item, thematic analysis was independently analysed by the first, second, and eighth authors. Themes were identified, suggestions for questionnaire improvement were studied, and modifications were made accordingly. Independent analysis confirmed the emerging themes.

2.3.4 Phase IV Test Evaluation and Revision

2.3.4.1 Field Try-out of Survey Questionnaire

The draft tools were administered for field validation among students, teachers, school principals, and community people wherever required, and data was collected for qualitative and quantitative analysis. Five schools of Raipur Chhattisgarh were selected for validation of tools.

Data Collection through the Unstructured Interview

The tools were administered in four government schools of Raipur, Chhattisgarh, for field validation. Resource persons also interacted with the learners, teachers, teacher educators, and education administrators separately through an informal, unstructured interview regarding tools, such as:

1. Learners, teachers, school heads were subjected to informal interviews about the tool items if they are understandable.
2. Whether the language of the items in the tools was easily understandable?
3. Is there any item in the tool which had not been taught in the class by the time the tools were administered?
4. How much portion of the syllabus was covered in the class?
5. Are the items in the tools locale-specific?
6. Is there any ambiguity/confusion in the stem of items or in the four options?

Tool Administration and Data Collection

The draft tools were administered for field validation among students, teachers, school principals, and community people wherever required, etc., and data was collected for qualitative and quantitative analysis. Five schools of Raipur Chhattisgarh were selected for validation of tools.

2.3.4.2 Data Analysis: Quantitative data from the pilot study were entered in SPSS version 16, and Kuder Richardson formula 20 (KR 20) was calculated to determine the internal consistency of the questionnaire.

2.4 Sample and Sampling Techniques

The sampling technique was purposive, and government schools at Raipur were chosen where the permission of piloting the instrument was granted by the interference of SCERT, Raipur, Chhattisgarh. The population of interest was students at the upper primary stage, teachers teaching science at the upper primary stage, school heads, and community for informal interaction. Total 504 students;164 from Class VI, 168 from Class VII, and 172 from Class VIII participated and filled up the tools number 1 and 2 as mentioned in Table 5 for assessing attainment of learners in learning science for Classes VI, VII, and VIII (TALS) and tool for assessing the attitude of learners in learning science (TATLS). A gender-wise sample of learners who took part is depicted in Table 3. However, science teachers of the same schools provided their feedback on Tool for Performance Indicators for Teachers (TPIT), and school heads of the same school provided feedback on the Classroom Observation Schedule (COS). In addition, faculty members from DIET Korba and Kanker provided their feedback on the school observation schedule (SOS).

Table 3

Sample Size: Class-wise Students' Participation

Class	Number of female students participated	Number of male students participated
VI	118	46
VII	129	39
VIII	105	67
Total	352	152
Total number of students' participation = 504		

The present study sample was drawn using multistage sampling techniques in identified schools at Raipur, Chhattisgarh.

Table 4

Identified Schools for Field Try out of Tools/Instrument

S.No.	Name of School
1.	Shaskiya Poorv Madhyamik Abhyas Shala, Shankar Nagar, Raipur
2.	J R Dani Govt Girl Hr Sec School, Raipur
3.	Govt Higher Sec School, Lalpur, Raipur
4.	Shaskiya Poorv Madhyamik Shala, Khamardeeh, Raipur

Sampling is done using the saturation sampling technique where the researcher reaches a point where no new information is obtained from further data. Saturation sampling determines the size of the sample in research, indicating that adequate data has been collected for a detailed analysis, basing it on the particular case that is being studied.

3. Results and Discussion

In this section, phase-wise findings from each of the three study approaches have been described by the authors while developing the instrument:

Phase I

3.1 Preliminary Investigation

Findings of material, students, competency, and front-end analysis are presented here.

3.1.1 Material Analysis

Textbooks are in the Hindi language. Development of word power in tribal language after every chapter in the textbook has also been observed (SCERT, 20).

3.1.2 Student and Teacher Analysis

In general, there is a lack of understanding of the concept and importance of the quality of the teaching-learning process. Lack of availability of qualified science teachers in schools of interior areas.

3.1.3 Competency Analysis

Since the state shares its boundaries with seven states of India, the culture and language of the state are considerably influenced by the culture of neighbouring states resulting in a mix of diversified cultures and dialects. This is the reason many languages and dialects are spoken in the state.

According to Census 2011, scheduled tribes population is 30.6 per cent of the total population, and this is why there is a lot of indigenous knowledge system along with well-developed deep-rooted life skills ingrained within every person in the community.

3.1.4 Front-end Analysis

Science textbooks of Chhattisgarh must be referred for developing items.

The items in the student's questionnaire must be in Hindi language (Maneesriwongul and Dixon, 2004).

The items must include contextual or local-specific items and also must include local language inputs.

The items must assess local and cultural competency in science.

Phase II

3.2 Design

Findings of design of instrument are presented in this section using expert opinion.

3.2.1 Expert Opinions

For the development of an instrument, research team members, along with the experts' opinion, identified the following areas for the construction of tools:

1. Learning of science concepts by learners.
2. Learners' attitude of learning science.
3. Role of science teacher as facilitator in teaching and learning of science.
4. Classroom interactions between learners and teachers.
5. Conduciveness of the learning environment for optimum learning attainment.

As a result, five types of tools were finalized, as mentioned in Table 5.

Table 5

Tools for Measurement of Teaching Learning of Science in Two ST Dominated Districts of Chhattisgarh

S. No.	Tools Developed
1.	Tool for assessing attainment of learners in learning science for Classes VI, VII, and VIII (TALS)
2.	Tool for attitude of learners in learning science (TATLS): To understand the degree of the attitude of learners in learning science
3.	Tool for Performance Indicators for Teachers (TPIT): To understand the role of the teacher as a facilitator
4.	Classroom Observation Schedule (COS): To understand how much classroom process facilitates learning science
5.	School Observation Schedule (SOS): To understand how much conducive is the school environment in the learning of science

Phase III
3.3 Realisation and Construction

Findings of expert opinion for construction of all five types of tools mentioned in Section 3.2 are presented in this section.

3.3.1 Tool for assessing attainment of learners in learning science for Classes VI, VII, and VIII (TALS): For the construction of this tool following two major domains were identified for item development:

(i) *Class-wise:* As emerged with the expert opinion, assessment items were developed from the science curriculum for upper primary Classes VI, VII and VIII separately and with due consultation of the curricular material in-force in Chhattisgarh state.

(ii) *Theme-wise* (Table: 6): Items may be developed theme-wise. The science is taught at the upper primary stage around the seven potentially cross-disciplinary themes (NCERT, 2006). For better insights and analysis, themes were separated under the three thematic groups I, II, and III based on the nature of the individual theme.

Table 6

Distribution of themes under the science syllabus at the upper primary stage

Thematic Group 1	Thematic Group 2	Thematic Group 3
How Things Work; Moving Things, People, and Ideas; Natural Phenomena	Materials; Natural Resources	Food; The World of the Living

Writing of items: A large number of items for each dimension were developed by the research team members in this study with the help of science textbooks developed by NCERT and SCERT, Chhattisgarh for Classes VI, VII, and VIII. The number of items

developed in each domain as per the theme-wise and class-wise distribution of concepts in the syllabus is presented in Table 7. The tool was developed in the Hindi language as Hindi is a speaking language with many changing dialects in Chhattisgarh State.

The items in the tool were incorporated to assess learners' science learning, keeping in view the learning outcomes addressing various scientific competencies such as, to identify, to differentiate, to classify, to conduct simple investigations, to relate processes and phenomena with causes, to explain processes and phenomena, to write word equations, to measure and calculate, to draw labelled diagrams, to plot and interpret graphs, to construct models, to discuss and appreciate the story of scientific discovery, to apply learning in scientific concepts, to make efforts to protect the environment, to exhibit creativity and values of honesty and various skills in science such as to observe, recall, provide logical reasons, think critically, be creative, analyze and interpret, apply learning in solving problems, etc.

There were three sets of questionnaires, Set I, Set II, and Set III. Fifteen items in each set were common; five items each from thematic group I, thematic group II and thematic group III. Rest of the items in Set I, Set II, and Set III were from thematic group I, thematic group II and thematic group III, respectively.

There was no definite number of items in each of the sets because the syllabus and textbooks of Chhattisgarh state for Classes VI, VII, and VIII revealed that there is not an equal distribution of the concepts from thematic group I, thematic group II and thematic group III in each class; such as, in Class VII, more concepts of thematic group III are being included, however, in Class VIII, more concepts in thematic group I are being covered.

3.3.2 Tool for Attitude of Learners in Learning Science (TATLS)

The tool was conceptualised to collect the information for students' approaches towards learning science. The questionnaire was developed with the intention to acquire information about students' interest in learning science and identify the behavioural gaps in the process of learning science. In the questionnaire, items were included which assess learners' interest in learning science and learning gaps while learning science. In addition, items were also included which assess students' awareness about the importance of learning science.

This questionnaire contained two parts, Part I and Part II. Part I was meant for information about the identity of the learner, their school name, science teacher, district name, gender, etc. Part II includes three sub-sections. Each subsection has a few items. Each item has five options. Out of these five options, one has to select one. The options against each item are agree, completely agree, can't say, disagree, and completely disagree.

Each item in this questionnaire was written under one of the following three dimensions:

- Learning and Interest in Science
- Perceptions about Teaching-learning Strategies
- Importance of Science

3.3.3 Tool for Performance Indicators for Teachers (TPIT)

The draft tool (PINDICS) developed by NCERT (2015) was used, and science

teachers of selected schools provided their feedback for a few modifications. The tool was administered by teachers to assess themselves as a facilitator in the teaching and learning of science at the upper primary level. Thus, it provided the data of teachers' self-assessment in teaching science. The test has two parts. Part I is for personal information, and Part II is for gathering information related to the practice of teaching. Part II comprises the following six dimensions.

- Designing Learning Experience
- Learning Strategies and Activities
- Classroom Management and Learning Environment
- Assessment and Feedback
- Professional Development
- Mechanics

Each item may be answered by respondents on a 5-point rating scale. These five points are never, seldom, periodically, consistently, and not applicable. Therefore, each teacher has to rate themself against each item under any one of these five categories which they feel best suitable with their teaching-learning process (NCERT, 2015).

3.3.4 Classroom Observation Schedule (COS)

The tool was conceptualised to gather information about the process and methods of teaching and learning of science in the classroom. The objective of this questionnaire was to understand the teaching and learning process in the classroom. While developing this tool, following aspects were considered:

(i) Whether the teaching and learning are learner-centric?

(ii) Whether the teacher is facilitating learning keeping in view to enhance learner's competency?

(iii) Is the pedagogy appropriate for learning various concepts?

(iv) Whether the learning is active or passive?

(v) Is there any experiential learning/ performing activities?

(vi) What available resources were used in the teaching and learning process?

(vii) How the aspects of values were integrated during the teaching and learning process?

(viii) How is the assessment integrated into the teaching-learning process?

(ix) Does the classroom process follow any lesson plan for learning?

(x) Do they follow some activities beyond textbooks for learning science?

(xi) Do they follow some activities beyond the classroom for learning science?

(xii) Are there any teachers' misconceptions about any concept in science?

(xiii) What is the degree of learners' reading, writing, and comprehension skills?

The tool was administered in a classroom situation by DIET faculty members and feedback was provided.

Item writing: Finally, for the development of the tool, five dimensions were identified:

1. 'Preparation made by the Teacher before the Classroom Teaching', comprising 5 items.

2. 'Interaction in the Classroom' comprising 15 items.
3. 'Handling Student Responses' comprising 6 items.
4. 'Engagement with Teaching-learning Resources' comprising 7 items.
5. 'Class Organization' comprising 4 items.

Thus, the tool comprises a total of 37 items to be administered at the time of the classroom process.

3.3.5 School Observation Schedule (SOS)

The tool was conceptualised to collect information about the school climate, including infrastructure, learning resources, school environment, etc. Therefore, the test was developed in the following eight dimensions.

1. Teacher availability
2. Teacher development
3. Time table
4. Resource availability
5. Science laboratory facility
6. Library facility
7. ICT integration in teaching-learning
8. Health, hygiene, and sanitation

The tool was developed for administration among school heads/principals for feedback.

The tool was developed under eight dimensions to gather information about the school environment. The first dimension is entitled 'Teacher availability.' There are five questions in this dimension. The second dimension is entitled 'Teacher development,' and it has four questions. The third dimension is 'Timetable,' and it has two questions. The fourth dimension, 'Resource availability,' has 12 questions. The fifth dimension, 'Science laboratory facility,' has six questions. The sixth dimension, 'Library facility,' has six questions. The seventh dimension is 'ICT integration in teaching-learning and, it has only one question. The eighth and last dimension is 'Health, hygiene, and sanitation, there are 16 questions in this dimension. Thus, there are 52 questions in this test. The test comprises both close-ended and open-ended type of questions.

3.4. Focus Group for Expert Validation of Draft Questionnaire

The experts' group reviewed all the tools, and necessary corrections were made with the panel of experts.

3.4.1 Tool for Assessing Attainment of Learners in Learning Science for Class VI, VII, and VIII (TALS)

The TALS was reviewed based on the following criteria, and a total of 647 items was finalised for field try out (Table 7):

1. Option given in multiple-choice questions were reviewed and finalised for ambiguity, editing for appropriate and easily understandable language, difficulty level, attainment of competencies, etc.
2. Items were modified for assessment of understanding the concept, problem-solving skills, critical thinking, and creative skills.

3. Appropriate splitting or clubbing of items were carried out.
4. Items from the whole syllabus were included.

All the tools were reviewed by subject experts from Chhattisgarh state, keeping in view the following points:

1. Contextualisation: The items were modified as per the local context
2. Cultural inputs
3. Language efficiency
4. Difficulty level in the context
5. Content cognition in the context

Table 7

Number of Items finalised (TALS)

Dimension		Number of items	Total number of items
Class VI	(Set I) Thematic Group I	46	196
	(Set II) Thematic Group II	53	
	(Set III) Thematic Group III	97	
Class VII	(Set I) Thematic Group I	44	166
	(Set II) Thematic Group II	27	
	(Set III) Thematic Group III	95	
Class VIII	(Set I) Thematic Group I	67	285
	(Set II) Thematic Group II	98	
	(Set III) Thematic Group III	120	
Total number of items	Science	647	647

Table 8

Local Specific Inputs in TALS

Criteria	Examples	Concepts on which Items are based
Contextualisation: The items were modified as per the local context	The tribes of Chhattisgarh depend on agriculture and forest produce for their livelihood.	Hybridisation techniques, blue-green algae in agriculture, hybrid varieties of animals, cattle, apiculture, legume crops, crops, nitrogen fixation, humus, fibers, and fabrics common diseases in plants and animals, weeds, agriculture, and forest products, etc.

Cultural inputs	Each house in Chhattisgarh, there is a Mahua drink-making unit	Separation process.
Language efficiency	After every five kilometres, the dialect in Chhattisgarh changes, and, therefore, textbook gives a list of the meaning of popular words.	Naphthalene balls have been written as damarkigoli, the enzyme is written as rukshansh; all items are in Hindi.
Difficulty level in the context / Content cognition in the context	Tribes of Kanker do rear cows for cow-dung to be provided for high agricultural produce, not for milk.	Milk to curd process, pasteurisation of milk.
Environment and surroundings	The rich biodiversity of Chhattisgarh state.	It includes items to assess learners understanding about their surroundings; such as Saprophytes, e.g., mushrooms; parasites, e.g., Amarbel; amphibians; annual, biennial, perennial plants, types of soil, rusting, LPG as fuel, materials, and minerals, galaxy, adaptation in plants and animals, the food chain.
Textbook	National context	Respiration in seeds, acid rain, uses of petrol in a motor vehicle, not as fuel, lens and mirror, chemical reactions, insulator and non-insulator, diseases of importance, a test of carbohydrate, natural phenomena and processes, measurements, cell structure.

3.4.2 TATLS, TPIT, COS and SOS

The TATLS, TPIT, COS, and SOS were reviewed based on the following criteria, and items were finalised for field try out (Table 8):

1. Options given in multiple-choice questions were reviewed and finalised for ambiguity, editing for appropriate and easily understandable language, etc.
2. Items were modified for appropriate assessment and data collection for learning gaps and learning environment.
3. Appropriate splitting or clubbing of items were carried out.

Phase IV

3.5.1 Field Try-out of Survey Questionnaire

Results presented in Table 9 reveal KR 20 values (Kuder Richardson formula 20) to determine the internal consistency of the questionnaire.

Analysis by item response theory may suggest a modification or dropping or retaining of each item with a goal of improving measurement accuracy.

It is recommended that since there are no items in the TALS that can assess the

Table 9

Class-wise and theme-wise KR20 value for TALS

Dimensions		KR20 value
Class VI	(Set I) Thematic Group I	0.38
	(Set II) Thematic Group II	0.36
	(Set III) Thematic Group III	0.32
Class VII	(Set I) Thematic Group I	0.33
	(Set II) Thematic Group II	0.39
	(Set III) Thematic Group III	0.45
Class VIII	(Set I) Thematic Group I	0.37
	(Set II) Thematic Group II	0.39
	(Set III) Thematic Group III	0.41

It was analysed that the internal consistency of the questionnaire tool, TALS is less than 6. Thus, analyses of individual items need to be carried out based on which individual items may be retained, modified, split, or clubbed.

3.5.2 Analysis for TATLS, TPIT, COS and SOS

Analysis of items of these tools was based on the feedback received by learners, teachers, school heads, and faculty members from DIET while administration of tools was done in selected schools at Raipur. Finally, the tools were finalised based on the analysis of feedback with the panel of experts with language editing and minor changes.

4. Recommendations

Statistical Analysis of TALS indicates very little internal consistency, and thus it is important to analyse each item individually using other methods.

reading, writing, and comprehension of middle-stage learners, some open-ended items may be given, so that reading, writing, or comprehension of learners may also be assessed. These open-ended questions may be on the same concept as given in multiple-choice items to assess the genuine understanding and attainment of learning outcomes.

5. Limitations

1. Field validation of questionnaires was carried out only in four government schools of Raipur. Therefore, it is a very small sample to finalise an error-free assessment tool.
2. Though the dialect in the Chhattisgarh state of India changes even within the periphery of five kilometres, it is difficult even after local specific language editing exercises for finalisation of tools, the tools may not be accurate and very suitable for all.
3. Though the assessment tools are to be developed to find out the gaps in learning, teaching-learning process, and learning environment for science learning, it is limited largely to assessing the academic aspects of quality.

6. Conclusion

In the present study, four tools have been finalised for administration in the given sample in selected schools in tribal-dominated rural schools and to study the baseline status of teaching and learning of science to find the gaps. However, tools for assessing learners' attainment in learning science for Classes VI, VII, and VIII (TALS) may be improved by using other methods of analysing individual items. Further research is needed to finalise these items. Further, through administering these assessment tools in experimental groups, researchers may point out the gaps in some aspects of quality that may provide insights or may be of interest to policymakers, education administrators, curriculum developers, and researchers who want to work for different studies related to interventions for the achievement of quality.

Acknowledgements

Research team members acknowledge the financial support and encouragement provided by the Director, NCERT for carrying out this work through PAC-approved programme Code 6.01 and 6.02 during 2015–16 and 2016–17.

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AWARENESS OF SOCIO-SCIENTIFIC ISSUES AMONG THE HIGHER-SECONDARY STUDENTS

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Science and society are interdependent and all aspects of science are inseparable from the society from which they arise. Today, society is continuously confronting numerous issues concerned with health and environment like cloning, ozone depletion, etc. These issues emerged from the interactions of science and society hence it is important to create awareness towards socio-scientific issues among students. The main aim of present paper is to study the awareness of socio-scientific issues among the higher secondary students. For this purposes researchers used self-developed 'Awareness of socio scientific issues' tool. This tool was administered on 654 higher secondary school students. It was found that majority of students are not aware of socio-scientific issues. In addition, it was also found that awareness of socio scientific issues among students is influenced by gender, board, academic discipline whereas it is not influenced by locality of students. Findings of research urge the need to develop suitable syllabus, textbook and teaching strategies so that it increases the awareness among students towards socio scientific issues.

Keywords: Awareness, Socio-scientific issues, Higher-secondary student

Introduction

The world around us has been increasingly shaped by science and technology. It also acts as a tool which can remove all those evils and constraints which may hamper the progress of the nation. It continues to advance day by day on a global basis, it is, therefore, essential for people to be prepared for these changes which are only possible when they become scientifically literate. Viewing the presence and importance of science in all walks of life and to prepare students to cope these changes educators, policymakers and reformers advocated science education for every child, at least up to a certain level of schooling. As a result of which science has become compulsory up to a certain level of school education in most of the countries. In India, Education Commission (1964–66) also recommended for compulsory science education up to Class X which was implemented in 1975, since then Science became compulsory for all students up to Class X, as a part of general education. The basic aim of general science education was not just limited to producing scientists but to create a scientifically literate citizenry able to use scientific knowledge in dealing with socio-scientific issues.

Science and society are interdependent and all aspects of science are inseparable from the society from which they arise but the socio-scientific issues exhibit certain unique characteristics, societal interests, effects and consequents (Sadler, 2002; Sadler and Zeidler, 2004).

Today, society is continuously confronting numerous issues concerned with health and

environment like cloning, gene therapy, stem cells, genome projects, ozone depletion, global warming, climate change, alternative fuels, nuclear energy, etc. (Kolsto, 2006; Sadler, 2003, 2004b; These issues emerged from the interactions of science and society and hence termed as socio-scientific issues (Eggert and Bogeholz, 2009; Kolsto, 2001; Sadler, 2004; Zeidler, et al. 2002). So while dealing with issues one confronts two kinds of questions, the first question is framed from the perspectives of ethical, personal or social scenario while the second question involves the scientific aspect of the issue (Kolsto, 2006) The use of the term socio-scientific issues (SSI) in the literature is found as far back as the 1980s (Zeidler, 2014).

As defined by Sadler (2004b), socio-scientific issues are societal dilemmas with conceptual, procedural, or technological links to science. Eggert and Bogeholz (2009) posited "socio-scientific issues are complex in nature and typically do not have a clear-cut solution. While they have their basis in science, they cannot be solved by referring solely to scientific knowledge. Rather, they involve various societal aspects and have to be resolved through the integration of different, often competing, perspectives" (p. 231)

Barrett and Nieswandt (2010) posited that socio-scientific issues are "complex problems— that involve— scientific data as well as ethical considerations". Zeidler (2003) explained the meaning of socio-scientific issues (SSI) as issues that involve the deliberate use of scientific topics that require students to engage in dialogue, discussion, and debate. They are usually controversial in nature but have the added element of requiring a degree of moral reasoning or the evaluation of ethical concerns in the process of arriving at decisions regarding possible resolution of those issues. The intent is that such issues are personally meaningful and engaging to students, require the use of evidence-based reasoning, and provide a context for understanding scientific information (cited in Zeidler and Nicholas, 2009).

The recent NCF-2005 emphasised the active participation of the learner in the construction of their knowledge. It suggested the basic criteria of validity of a science curriculum. Content validity and process validity were related to the components of scientific literacy, whereas environmental validity was linked to socio-scientific issues.

The national focus group on teaching of science (NCERT, 2006) suggested that science curriculum up to Class X should be oriented more towards developing awareness among the learners about the interface of science, technology and society, sensitising them, especially to the issues of environment and health, and enabling them to acquire practical knowledge and skills to enter the world of work (p. 11).

It further expressed that in the contemporary society numerous socio scientific issues (with science as well as social, political and ethical links) emerge, so curriculum up to Class X should be designed to develop awareness among students about these issues. Hence, it described the application of scientific knowledge as one of the general aims of science education. It stated that science education should enable the learner to know the facts and principles of science and its applications, consistent with the stage of cognitive development (p. 11).

In the light of the above discussion, it has become clear that since very long, our

educational policies and reforms documents acknowledged the importance and need of the scientific literacy and connecting science to the everyday life so that a scientifically literate citizenry, able to make appropriate decision on socio-scientific issues could emerge and contribute to the development of the country.

In India and abroad, various researches have been conducted to explore scientific literacy and socio scientific issues in the last few decades. Laugksch and Spargo, 1996; Raza, et al., 2000; Mythili, 2002; Shwartz, et al., 2006 and Paula, 2007 have assessed scientific literacy among participants. Yates, 1998; and Foster and Shiel-Rolle, 2011 have studied the factors influencing scientific literacy. Nwagbo, 2006; Carlson, 2008; Webb, 2009; Mahatoo, 2012 and Nikam, 2013 have made strategies to improve scientific literacy. Awareness of socio-scientific issues was assessed by Chang Rundgren, 2010. Sadler, et al. (2006) and Malhotra (2017) investigated the teachers' perceptions on the teaching socio-scientific issues. They found that teachers' belief, school leadership and assessment system are the most influential factors for socio-scientific issues. Kolsto (2006), Pinzino (2012) and Rundgren, et al. (2016) have studied students' argumentation and decision making to authentic socio-scientific issues.

Reviews related to socio-scientific issues rendered us essential information like students practices (reasoning, argumentation and decision making) in the context of socio-scientific issues. Some researchers explored how students negotiate information provided regarding socio-scientific issues and some explored the role of teachers, teaching models in enhancing the skills required to deal with socio-scientific issues. But the researcher has not found any relevant study that assessed the awareness of socio-scientific issues in higher secondary students. As higher secondary students have completed the general science education, their awareness of socio-scientific issues could provide useful information. In the absence of comprehensive information it is hard to say whether the objective of making them aware of socio-scientific issues has yet achieved or not. Thus a research gap was perceived and, therefore, it was imperative to undertake the study that could provide information about the current status of awareness of socio-scientific issues in students. Hence, the researcher selected the problem for the detailed and extensive study.

Research Questions

What is the level of awareness of socio-scientific issues among the higher secondary students?

Statement of the Problem

Awareness of socio-scientific issues among the higher secondary students.

Objectives

1. To study the awareness of socio-scientific issues among the higher secondary students.

(a) To compare the awareness of socio-scientific issues among the higher secondary students on the basis of

(i) Gender (male and female)

(ii) Locality (rural and urban)

(iii) Board (Central Board of Secondary Education (CBSE) and Uttar Pradesh Madyamik Shiksha Parishad (UPMSP)

(iv) Academic discipline (science and non-science)

Hypotheses of the Study: The null hypotheses tested at 0.05 level of significance as given below:

H01: There is no significant difference in the awareness of socio-scientific issues of male and female higher secondary students.

H02: There is no significant difference in the awareness of socio-scientific issues of higher secondary students on the basis of rural and urban locality.

H03: There is no significant difference in the awareness of socio-scientific issues of higher secondary students on the basis of enrolment in CBSE and UPMSP.

H04: There is no significant difference in the awareness of socio-scientific issues of higher secondary students on the basis of science and non-science discipline.

Operational Definition of Key Terms

1. *Awareness of Socio-scientific Issues*

In the present study the awareness has been defined as the awareness of scientific and social aspects of the socio-scientific issues. It is represented by the scores obtained by higher-secondary students after filling the awareness tool for socio-scientific issues Tool for Awareness of Socio-scientific Issues (TASSI).

2. *Higher Secondary Students*

In the present study higher secondary students have been defined as all those students who were enrolled in Classes XI and XII of CBSE and UPMSP schools in Varanasi.

Methodology

The present study was a descriptive study with cross-sectional survey design. All the higher secondary students of Varanasi enrolled in various schools affiliated to CBSE and UPMSP constituted the population of the study. As the population of the study was heterogeneous with respect to demographic and academic factors, stratified random sampling technique was used to draw the sample for the study. The sample consisted of 654 higher secondary students which were drawn from the strata constituted by the board, gender and academic discipline. The total respondents were 700 in number, of which the response sheets of 46 were incomplete and hence rejected. TASSI tool was used by the researcher to collect the data of awareness of socio-scientific issues among higher-secondary students. This tool consisted of 40 multiple choice questions related to socio-scientific issues (SSI).This tool includes two domains of SSI, i.e., health and environment. Health domain included items related to diseases, causes of diseases, cure of diseases and medical technologies. Saving environment, pollutions, wildlife and environmental laws/plans/agreements are the sub-domain of environment. The reliability of the tool was 0.711. The tool had face validity and content validity. Percentile norms were established for this tool.

Delimitations

1. The population was confined to Varanasi city.
2. The sample was derived from the schools affiliated to CBSE and UPMSP only.

Result and Discussion

Data collected through TASSI was analysed by using Data Analysis Tool Pack of MS Excel software. Descriptive analysis was done by using percentage, and independent samples t-test was employed for inferential analysis. Objective wise analysis has been done. One of the primary objectives of the present study was to study the awareness of socio-scientific issues among higher secondary students. It was measured by using TASSI. For being aware of socio-scientific issues, the higher secondary students needed to answer 24 or more questions correctly, or else they were declared as not aware of socio-scientific issues. The table shows the distribution of socio-scientific issues among the higher secondary students according to their marks obtained in TASSI.

Table 1

Awareness of socio-scientific issues among higher secondary students

Marks obtained	Number of students	Percentage	Total
>24	247	37.77%	654
<24	407	62.23%	

The above table reveals that majority of higher secondary students are not aware of socio-scientific issues as only 37.8 per cent of students have correctly attempted 24 or more questions on TASSI. Chang Rundgren (2010) investigated the awareness of three socio-scientific issues regarding certain variables and Yoonjeong, et al. (2016) also investigated elementary school students' awareness about socio-scientific issues and solutions about environmental topics but they did not attempt to assess the overall awareness among respondents. The present study is supported by Dawson (2015) who found that only one in three students (156, 35%) were able to provide a correct or partially correct response about the socio-scientific issue, greenhouse effect. To the best of the researcher's knowledge, no other study was conducted to assess the awareness of socio-scientific issues, so comparison is not possible. However, many factors could be asserted for the low rate of awareness of socio-scientific issues in higher secondary students. One of the basic constraints is prevailing examination system based on rote learning (NCERT, 2005). The other constraint is that the textbooks are overloaded with information. Though, textbooks are primary instruments for universalisation of good science education and instrument to realise the basic curricular objectives (NCERT 2005), but the upper primary textbooks of NCERT have superficially discussed the socio-scientific issues, more than that, their impact on society are also not discussed properly (Singh and Singh, 2018). So there is not enough scope for wider and participative discussions on socio-scientific issues. It is also hard for teachers to cover a large content based syllabus along with relating the scientific knowledge to the everyday life in limited time. Therefore, about 62 per cent of the students are not aware of socio-scientific issues.

The second objective of the present study is to compare the awareness of socio-scientific issues among the higher secondary students on the basis of gender (male and female), locality (rural and urban), board (Central Board of Secondary Education (CBSE) and Uttar Pradesh Madyamik Shiksha Parishad (UPMSP) and academic discipline (science and non-science)

Gender and Awareness of Socio-scientific Issues

Table 2

Summary of t-test regarding awareness of SSI of male and female higher secondary students

Particulars	Male	Female	α	df	Critical t value	Calculated t value
Mean	21.542	22.369	0.05	652	1.963	2.046
Variance	29.778	23.624				
Observations	315	339				

Significant at the level of significance P←0.05

Table 2 revealed that the table value of t for df = 652 is t0.05 = 1.96. The computed t-value for gender was 2.046, which was found significant at 0.05 level of significance for the degree of freedom 652. Hence, the null hypothesis 1, i.e., "There is no significant difference in the awareness of socio-scientific issues of male and female higher-secondary students" was not accepted. From the result, it can be said that in the current study there exists a significant gender difference in the awareness of socio-scientific issues of male and female higher secondary students. It means that female students performed better than male students on TASSI and hence, female students are more aware of socio-scientific issues than male students.

Although there have been many studies (Kara, 2012; Chang Rundgren, 2010 and Rizal, et al. 2017) that show no significant gender difference in socio-scientific issues but the findings of the present study revealed the significant gender difference in terms of awareness about socio-scientific issues.

Likewise, the present investigation Ekborg and Ottander (2010) in their study revealed a significant difference between how girls and boys judge the socio-scientific issues. Sadler and Zeidler (2003) concluded that besides scientific knowledge, other factors such as affective dimensions influence the argumentation in socio-scientific issues. Watts (2000) also argued that various factors like disappointment, disaffection, distaste, aversion as well as challenge, enjoyment, pleasure, and fulfillment influence the appreciation and learning of science. Reddy (2017) found that girls prefer biology while boys are interested in physics and chemistry. Kahle, et al. (1993) found that Australian teachers responded that girls performed better than boys in biological science. He also found that "boys, on average, were more interested in science associated with matter and energy (including electricity), whereas girls were more interested in science associated with plants and animals". Findings of Fonseca, et al. (2011) also showed that girls are always better than boys for the Identifying Scientific Issues competency (ISI). Likewise, Rundgren, et al. (2016) also found that female students seemed to ascribe more weight to health risks in their argumentation than male students. Hughes (2000) also found that female students enjoy socio-scientific context while male students reject it.

Locality and Awareness of Socio-scientific Issues

The difference in the people dwells in rural or urban area is not just limited to their

localities but the rural-urban differences are also reflected in various aspects of learning, aspiration and achievement of students (McCracken, 1991; OECD, 2013c; and Sharma, 2007). NCERT (2006) also showed concern on rural-urban difference, it stated there exist a huge gap in education in general and science education in particular between the rural and urban students (p. 29). There are various explanations to these differences. Sharma (2007) differentiates urban and rural areas explaining that socio-economic inequalities separate the two. McCracken (1991), and OECD (2013c) found significant differences in the students of urban and rural schools. NCERT (2006) considers poor infrastructure, inadequate support systems, lack of access to information and resources in rural areas are responsible for these differences. In the current study the schools selected for data collection were located in urban areas but the students enrolled there were from urban as well as rural backgrounds. Therefore, the researcher compared the students of rural and urban backgrounds for awareness of socio-scientific issues.

It is evident from Table 3 that the table value of t for df = 652 is t0.05 = 1.96. The computed t-value for gender was 1.575, which was found to be non significant at 0.05 level of significance for the degree of freedom 652. That is why, the null hypothesis 2, i.e., "There is no significant difference in the awareness of socio-scientific issues of higher secondary students on the basis of rural and urban locality" was accepted. It is revealed from the above result that students' performance on TASSI was equivalent, so locality background doesn't influence the socio-scientific issues.

In this study, the students with rural background were enrolled in urban schools so the constraints that limit the performance of students due to rural schools were not there. Rural students help their parents in farming, graze animals, they commonly identify and use a variety of plants as sources of food, medicines, fuel wood, dyes and building materials, they notice changes in season, so they have rich interactive experience of natural world (NCERT, 2006). Most science educators consider that students' knowledge and experience is vital for science learning (Duschl, et al. 2007). Nowadays science syllabus and textbooks also strive to link the students' life at school with outside world according to the recommendation of National Curriculum Framework (NCF, 2005). Textbooks also attempt to provide opportunities for contemplation and wondering, discussion in small groups and activities requiring hands-on experience (NCERT, Science Textbook). So the students, regardless of their rural background, are equally aware of socio-scientific issues.

Table 3

Summary of t-test regarding awareness of SSI of rural and urban higher secondary students

Particulars	Rural	Urban	A	Df	Critical t-value	Calculated t-value
Mean	21.413	22.090	0.05	652	1.963	1.575
Variance	27.833	27.920				
Observations	235	419				

Board and Awareness of Socio-Scientific Issues

The following table showed that the table value of t for df = 652 is t0.05 = 1.96. The computed t-value for board was 4.579, which was found to be significant at 0.05 level of significance for the degree of freedom 652. Hence, the null hypothesis 3, i.e."There is no significant difference in the awareness of socio-scientific issues of higher secondary students on the basis of enrolment in CBSE and UPMSP" was not accepted.

CBSE schools. According to Thareja (2015), CBSE is extremely focused on Science and Mathematics with a lot of attention paid to the application of knowledge. CBSE approves both Hindi and English as the medium of instruction so the students become competent in both the languages and they become able to apprehend information regarding socio-scientific issues from variety of sources. So the higher secondary students of CBSE were found more aware of socio-scientific issues than their counterpart from UPMSP.

Table 4

Summary of t-test regarding awareness of SSI of CBSE and UPMSP higher secondary students

Particulars	CBSE	UPMSP	A	Df	Critical t value	Calculated t value
Mean	22.710	20.993	0.05	652	1.963	4.579
Variance	33.580	10.339				
Observations	352	302				

The result indicates that in the present study, there is a significant difference in the awareness of higher secondary students of CBSE and UPMSP. The students of CBSE performed better than students of UPMSP on TASSI and, therefore, they are more aware of socio-scientific issues.

A report on quality in school education found that facilities like online learning, use of Information, Technology and Communication (ICT) and multimedia are available to some extent in CBSE schools. So, CBSE schools are technologically advanced in comparison to UPMSP schools. Also, community participation in school activities is more common in

Subject and Awareness of Socio-scientific Issues

The aim of general science education for ten years for all students is to expose them to fundamental concepts of science so they could become scientifically literate (NCERT, 2005). Curriculum up to this stage is also set in a way to develop awareness among the students about the relationship of science, technology and society and sensitising them about the socio-scientific issues related to environment and health.

In the present study, the students who opted science subject combination at higher secondary stage have been considered as science students and those students who did not opt science (but opted arts or commerce) have been considered as non science students.

Table 5

Summary of t-Test Regarding Awareness of SSI of Science and Non-science Higher Secondary Students

Particulars	Science	Non- Science	A	df	Critical t value	Calculated t value
Mean	22.825	21.601	0.05	652	1.963	3.498
Variance	27.070	10.362				
Observations	360	294				

From Table 5 it can be seen that the table value of t for df = 652 is t0.05 = 1.96. The computed t-value for board was 3.498, which was found to be significant at 0.05 level of significance, for the degree of freedom 652. Therefore, the null hypothesis 4, ie,. "There is no significant difference in the awareness of socio-scientific issues of higher secondary students on the basis of science and non-science subjects" was not accepted.

From the above result, it can be said in the present study that there is a significant difference in the awareness of higher secondary students of science and non-science subject. The science students performed better than the non-science students on TASSI and therefore, they are more aware of socio-scientific issues. Similar to the results of current investigation, Zeidler and Schafer (1984) found that science students performed better than non-science students in moral reasoning about an environmental issue. They also substantiate the link between content knowledge and reasoning about environmental issues. Ratcliffe (1999) also found that science experience attained through science education develops evidence evaluation skills in socio-scientific issues in science students. She concluded that students with more experience of formal science education perform better than the science students with relatively less experience of formal science education. Yang (2004) found that students showing ambiguity on their thoughts about a SSI due to their insufficient information. Kolsto, et al. (2006) also found results similar to Yang (2004) with science education students. Sadler and Zeidler (2004) compared the content knowledge and informal reasoning about genetic engineering issues of two groups of undergraduate college students from natural science and non-natural science and found that the students from natural science performed better. They also found that content knowledge influence the variations in informal reasoning quality about socio-scientific issues. Similarly, Lin (2014) also found that science students performed significantly better than non-science students in critical thinking performance about a socio-scientific issue. Science students have more experience that turns into better science content knowledge. As the science students have relatively more exposure to content knowledge and scientific information, therefore, they are supposed to be more aware of socio-scientific issues than the non-science students. Thus, the average performance of the science students on TASSI was found significantly better than the non-science students.

Findings

- On the basis of the above result the researcher derived that majority of students are not aware of socio-scientific issues.
- Awareness of socio-scientific issues among higher secondary students is influenced by gender, board, academic discipline, whereas it is not influenced by locality of students. As in the present study majority of socio-scientific issues have origin from biological sciences, in which female students are found to be more interested than male students, that is why female students outperformed male students in awareness of socio-scientific issues.

Educational Implications

1. The study provides the empirical data of the awareness of socio-scientific issues in the students that can be used by policy makers to make strategies to increase the awareness of socio-scientific issues.
2. Findings of the study provide the information of the factors that influence the socio-scientific issues. Teachers can use this information to provide appropriate opportunities to enhance awareness among students.
3. Policy makers can also use this information to develop suitable syllabus, textbooks, content and teaching strategies.

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EFFECTIVENESS OF AUDIO-VIDEO MATERIAL IN TEACHING-LEARNING PROCESS AT SECONDARY STAGE

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This work is based on the use of audio-video resources in few schools of Delhi NCR with specific reference to five secondary schools opted for this study. The study had following purposes information about the types of audio-video teaching materials available in the schools, the frequency of their use, the steps school has taken in promoting the use of audio-video resources and the effectiveness of these resources in the teaching-learning process. Four questionnaires were administered in each school; two sets to science lecturers, one set to students and one set to administrative staff in order to explicate the above information. Data were collected, coded and analysed using statistical techniques like percentages for the easy analysis of data. Finally, it was unearthed that the schools collection of audio-video materials was inadequate. Audio-video materials were hardly used by the teachers for teaching. The only medium of instruction used was chalkboard method. Non-availability of e-resources, lack of supporting ICT infrastructures and lack of awareness about the utility of these e-resources in these schools was recorded. There are numerous benefits that students derive from the use of audio-video materials. The awareness of available audio-video resources created by these schools was not imposing.

Keywords: Audio-video material, teaching-learning, process, ICT

Introduction

According to NCF-2005, at the secondary stage, an important part of curriculum is to verify the theoretical principles by performing systematic experimentation. In today's digital age, technology enables us to transact learning resources in an effective way to a large number of learners. In view of this, audio-video materials will facilitate and promote use of technology in explanation of scientific concepts. E–pathshala, NROER and other such platforms also promote students to be constantly involved in the educational process through experiential learning.

According to Shamsideen, S.A. (2016), we all are living in an era where a child learns to operate gadgets much before they can even crawl. We are so overpowered by technology in every field and this influence can be very well observed in the education sector too. It has been observed that when a teacher used audio-visual aids instead of books to teach a concept to the students, it becomes clearer and also lasts in the mind of students.

Deeley, 2018 has stated that by taking small progressive steps and by using different types of interactive technologies, the students are benefited by gaining effective learning.

According to González-González, et al. (2015), audio-visual aids, namely, short films, storytelling, etc., help the students to understand the practical implication of the theory which has been explained in classroom teaching.

Oketunji, 2000 corroborates that when audio-video materials are used effectively, they

have certain advantages. The weakness of verbalism is lessened and the subject matter is more humanised, the topics are dealt with a new and interesting approach, it helps us save time and most importantly explicit content is supplied.

Anzaku, F. (2011) underlines that the term 'audio-video' material is used to refer those instructional aids which translate knowledge without the dependence on books and verbal symbols. Therefore, any reference material or textbook does not fall under this category.

ICT not only plays a vital role in teaching-learning of science for normal students but also for special students. There are some screen reader softwares used by visually impaired students like Job Access with Speech (JAWS) which is a computer screen reader programme for Microsoft Windows that allows the visually impaired students to read the screen either with a text-to-speech output or a refreshable Braille display, NVDA (Non Visual Desktop Access), etc.

Methodology

The study is a survey research type. This paper deals with the methods used by the investigator to find out:

- the use of audio-video materials and other assistive strategies (ICT) by the teachers to help the normal and special students in learning science.
- the frequency of the use of these audio-video learning materials.
- the awareness in schools regarding the effectiveness of audio-video materials and other assistive strategies in learning science.

So, in order to study the above, the investigator opted for the survey method. The audio-video materials based on laboratory safety and use of chemical balance were disseminated in schools of Delhi NCR, namely:

1. Salwan Public School, Rajender Nagar, New Delhi
2. Tagore International School, Vasant Vihar, New Delhi
3. NP Bengali Senior Secondary School, Gole Market, New Delhi
4. Kendriya Vidyalaya, JNU Campus, New Delhi
5. Government Girls Senior Secondary School, Vasant Kunj, New Delhi

Audio-video material dissemination in Government Girls Senior Secondary School, Vasant Kunj, New Delhi

Analysis and Interpretation of Data

The four questionnaires were disseminated in five selected schools of Delhi NCR— Salwan Public School, Rajender Nagar, New Delhi; Tagore International School, Vasant Vihar, New Delhi; N P Bengali Senior Secondary School, Gole Market, New Delhi; Kendriya Vidyalaya JNU Campus, New Delhi

and Government Girls Senior Secondary School, Vasant Kunj, New Delhi.

Students Feedback about the Use of Audio-video Materials

Many videos of secondary stage were shown to the students and teachers. Their views on some of the videos are as follows:

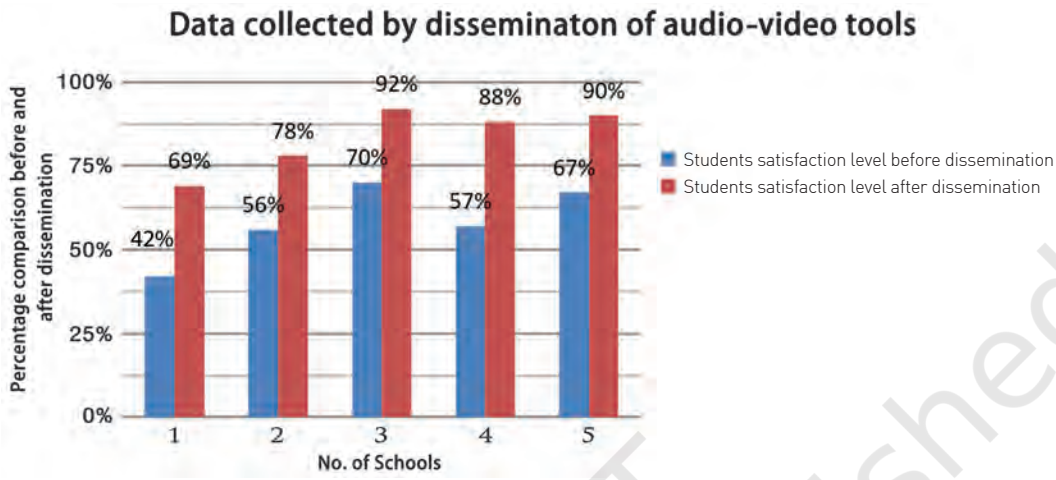
The students found the 'Science laboratory safety' video very helpful as most of them were not taught about the precautions one needs to take while working in a science laboratory and handling of corrosive chemicals. Also most of schools lacked chemical balance in their laboratory and in case it was present, the students were not introduced to it physically. Moreover, they emphasised on the importance of having an audio-video material for every theory topic they study as it will help them to learn and retain the topics better and for longer duration. They underlined that traditional verbal instructions become boring for them sometimes. However, the use of audio-video materials provided an intrinsic motivation by peaking up their curiosity in the topic.

Teachers Feedback about the Use of Audio-Video Materials

The teachers substantiated the need of audio-video materials in their classroom and also underlined the benefits of it by mentioning that they could incorporate numerous items in one audio-video lesson plan such as music, images, websites, etc. It allows the teachers to make customised content according to the need of students. According to most of the teachers, audio-video learning would help more students to participate in classroom discussions as it will save time from note-taking.

Table 1
Data collected by the dissemination of audio-video research tools

Schools	Students satisfaction level before dissemination	Students satisfaction level before dissemination
Salwan Public School, Rajender Nagar, New Delhi	42.0%	69.0%
Tagore International School, Vasant Vihar, New Delhi	56.0%	78.0%
N P Bengali Senior Secondary School, Gole market, New Delhi	70.0%	92.0%
Kendriya Vidyalaya JNU Campus, New Delhi	57.0%	88.0%
Government Girls Senior Secondary School, Vasant Kunj, New Delhi	67.0%	90.0%



It is evident from the above graph that in all the schools under study, teachers found a considerable difference in the opinion of students when they were asked about the clarity of conceptual understanding through practical implementation.

Conclusion and Discussion

Technology has a huge impact on the world of education these days. If it is used in a constructive way, then it can really help in building the conceptual understanding of students through a good practical implementation. ICT-integrated teaching in classrooms are observed by using audio-video tools and other assistive strategies in secondary classes. These tools were disseminated in five schools of Delhi-NCR and they were asked to fill a questionnaire after the implementation. As a result, students found these videos very interactive as well as sustaining in their minds. According to them, it built a substantial interest in the classroom by adding innovative practices.

Salwan Public School showed a 27 per cent progressive growth in the interest for learning chemistry practical at secondary level, Tagore International School and N P Bengali Senior Secondary School both showed a 22 per cent increase in the same. On the other hand, 31 per cent increase in students understanding of practical was observed in the Kendriya Vidyalaya JNU Campus and lastly 23 per cent students agreed on the benefit of audio-video materials in teaching-learning process in Government Girls Senior Secondary School, Vasant Kunj. The teachers lacked knowledge and expertise in using audio-video materials and other assistive strategies in schools. Regular science teachers were also not trained enough to deal with CWSN (Children with Special Needs). Moreover, the infrastructural facilities in most of the schools were not encouraging enough to opt for ICT-based learning.

Broadly translated, our findings indicate that a proper audio-video configuration in a classroom can not only help to deliver better content but also produce

more tech-savvy scholars. Audio-video materials such as Power Point Presentations (PPTs), Interactive White Boards (IWB) combined with educational software, Bring Your Own Devices (BYODs) like laptop, tablets , video conferencing, etc., are changing the effectiveness in a classroom and also assist the teachers in preparing and delivering the lectures more effectively.

Acknowledgements

I would also like to show my gratitude to my department, DESM (Department of Education in Science and Mathematics), NCERT for the kind cooperation throughout the course of this research, and I thank Central Institute of Educational Technology (CIET) for developing the audio-video materials and providing their insights.

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IMPLEMENTING A LARGE-SCALE ASSESSMENT SURVEY TO UNDERSTAND THE LEARNING LEVELS FOR POLICY IMPLICATIONS AND TO IMPROVE TEACHING-LEARNING

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The Ministry of Education (MoE), India, in 2017, conducted the National Achievement Survey (NAS) to understand the learning levels of the students in Classes III, V and VIII, to assist in policy implications and to improve teaching-learning. The survey tools used competence based multiple test questions, 45 in Classes III and V and 60 in Class VIII in mathematics, language, sciences and social sciences mapping the learning outcomes corresponding to the three grades. Questionnaires pertaining to students, teachers and schools were also used. The sample consisted of 2.2 million students from 1,10,000 schools across 701 districts from all 36 States/UTs. The results were analysed using both the Classical Test Theory (CTT) and the Item Response Theory (IRT). The findings of the survey helped to guide education policy and enabled differential planning at the district level for improving classroom level teaching-learning.

Keywords: Assessment, large scale studies, School education, National Achievement Survey.

Introduction

Large-scale assessments are common worldwide for understanding the trends in educational systems. In India too, the National Achievement Survey (NAS) provides an effective and a robust dataset for informed policymaking in the field of school education for the country.

NAS 2017, a school-based assessment, reports a fair and an accurate statement of the educational health at the district level for all States and Union Territories in India. It is technically robust and assess the learning levels of students at Classes III, V and VIII vis-a-vis the delineated grade specific learning outcomes.

Due to its large scale, NAS requires a careful and a detailed planning, execution and close monitoring of its implementation, using several quality-control measures. It was subject to scrutiny before national and international experts. During the test development process, each question went through standard technical rigours, while formatting and during translations into twenty languages, before final acceptance. A cadre of field investigators were trained to administer the tests, which was monitored with quality control checks at different levels. The raw data from each district were examined to make sure that no anomalies existed, and all analyses were scrutinised thoroughly. Finally, reports were transcribed, carefully reviewed, and then disseminated in a format suitable for the various stakeholders.

Methodology

Item Development

Test items (questions) were developed in English, through workshop mode, in consultation with teachers, subject experts

and several other assessment agencies in the country. Multiple Choice Questions (MCQ) were developed which consisted of stem (question) and four options (one correct and three distractors). Optical Mark Recognition (OMR) sheets were used during the field test for recording the responses. This was necessitated to obliviate ambiguity and consequent complications at the time of analysis. Efforts were made to develop items of varying degree of difficulty levels and complexities, for as many Learning Outcomes (LO) as possible. Illustrations/ diagrams were used to break the monotony. Developed tests were translated and field tested in 20 languages (Assamese, Bengali, English, Gujarati, Garo, Hindi, Kannada, Khasi, Konkani, Marathi, Malayalam, Manipuri, Mizo, Odia, Punjabi, Tamil, Telugu, Urdu, Bodo and Kokborok (a Sino-Tibetan native language of the Borok people of Tripura). Multiple test booklet matrix design was used wherein two test forms were developed for each class, consisting of 45 questions for Classes III and V and 60 questions for Class VIII. For each subject, first 5 items were kept common across both the test forms.

Contextualising the Student Achievement

In NAS, the participating students, their teachers and school principals completed questionnaires to provide data about school and classroom resources and to understand about students' home contexts for learning. Three questionnaires, i.e., Pupil Questionnaire (PQ), Teacher Questionnaire (TQ) and School Questionnaire (SQ) were developed and administered to study the association of the background variables with the achievement of the students in all the three grades.

Use of Technology

One of the major highlights was the use of technology. A web application developed to scan the OMR at the district level and to upload the .csv files to auto generate the district level reports.

Sample Selection

The sampling frame consisted of a comprehensive list of schools from the district. The district was taken as the unit for sampling. Each school entry in the frame had the following:

- a unique school ID
- school contact information such as name, physical address, email address, phone number, etc
- explicit stratification variables, i.e., the district name
- implicit stratification variables, i.e., block, area, management, type of school, and medium of instruction
- a school measure of size, i.e., the total number of students in the school

A two-stage stratified sample design was used as follows:

- For the first stage of sampling, schools were selected with probabilities proportional to size (PPS).
- The second stage of sampling consisted of the selection of section (if there were more than one section) in each sampled school.

NAS for Classes III, V and VIII required participation rates for schools and students to be 85 per cent. To compensate for a sampled

school that did not participate, two potential replacement schools were identified. The above requirement minimised the potential for response biases.

Training

Orientation of State Coordinators at the district level was provided by the National Council of Educational Research and Training (NCERT). District Coordinators (DC) and Management Information System (MIS) Coordinators were trained on NAS procedures through workshops organised, who in turn trained Field Investigators (FI).

Training was provided on the following aspects of NAS administration:

- Roles and responsibilities of different personnel involved in NAS administration
- Sampling of section and students in the schools selected
- Administration of test and questionnaires
- Test monitoring
- Data cleaning and uploading, etc

Sessions on all the above aspects were conducted through interactive and activity-based mode with the use of demonstration and group work as facilitation techniques. A comprehensive set of training material was shared with the participants prior to the commencement of the workshops with an aim for an enhancement in their understanding of the processes. Training material consisted of PowerPoint Presentation on administration and videos on roles and responsibilities of stakeholders, made available online along with sharing of the hard copies of the training module which laid down in detail the standard operating procedures. The complete training package is available at:

- http://www.ncert.nic.in/programmes/NAS/Training.html

Administration Process

The field investigators were drawn from amongst the teacher trainees from the colleges and institutes of education. The field investigators were given rigorous standardised training by the master trainers who in turn were trained by the National Council of Educational Research and Training (NCERT). A cadre of master trainers was developed by NCERT, who were subsequently responsible for training the FIs. To conduct NAS 2017, approximately two lakh field investigators were involved.

Over 6000 observers were appointed by the offices of the Chief Secretaries/Commissioners of every state/Union Territory (UT). They were drawn from amongst Class I and Class II officials of departments, other than the Education Department of the state/UT. These observers acted as third-party witnesses on the day of the NAS test, as a check on malpractices, if any.

Results and Discussion

Within the domain of psychometry, two approaches were used for analysing test data, i.e., Classical Test Theory (CTT) and the Item Response Theory (IRT). Though use of Item Response Theory (IRT) in analysing the results of the large-scale assessment is in vogue at the international levels, NAS 2017 utilised both the approaches, in accordance with the requirements of the stakeholders. The analysis for developing the district report

cards and State learning reports was done using a Classical Test Theory (CTT) and Item response theory was used to produce the National Technical report. The use of IRT becomes pertinent as it supports the test development process and construct validation. Also, the use of modelling in conjunction with multiple imputation methodology allowed the construction of a performance scale.

NAS 2017, through elaborate statistical analyses, produced outputs and created the following reports:

- District Report Cards (DRCs)
- State Learning Reports (SLRs)
- National Report, to inform Policy, Practices and Teaching Learning (NPPTL)

District Report Cards (DRCs)

District was taken as the unit of reporting. Within two months of the administration of NAS 2017, district level results, communicated through the DRCs, were put in the public domain (https://ncert.nic.in/DRC.php).

NAS was conducted in 701 districts and in each district, there were 10 report cards, three each for Classes III and V and four for Class VIII. Thus, there were in all 7010 report cards. The DRCs were developed with the primary purpose of communicating to the respective districts, the performance of their students, on the competencies spelt out on the Learning Outcomes (LOs). DRCs also indicate the LOs on which students performed the lowest and required maximum support.

Each DRC included information on the following heads:

- Overall learning levels of the district, shown by the overall performance of the district in a subject, i.e., a 55 per cent on science meant that students of a district correctly responded to 55 per cent of the items in science.
- Disaggregated learning levels by gender, location, social groups, and school management, depicted by the percentage of questions which various subgroups (e.g., boys and girls) correctly responded to in a subject.
- Performance against each of the learning outcomes, reported by student achievement against a LO, for example, a 45 per cent against a LO meant that 45 per cent of the students in a district could correctly answer the questions measuring the LO.
- Distribution of learning level shown by the range/number of students who correctly responded to questions in a class and a subject. Number of students scoring within each of the following four performance slabs were shown (below 30 per cent, 30-50 per cent, 50-75 per cent and above 75 per cent).
- Identify five learning outcomes on which children required maximal support.

State Learning Reports (SLRs)

There are in all 36 SLRs generated based on the NAS. After the production of the DRCs, a single State Learning Report (SLR) was developed for each State (and UTs). Each SLR gave an overview of the State's performance on all the tested LOs for each class and subject. Based on the SLR results,

State level officials were expected to provide academic support towards the district-wise implementation of interventions designed to improve student attainment of LOs.

- https://ncert.nic.in/src.php?ln=#:~:text=State%20Reports%202017%2D18&text=The%20National%20Achievement%20Survey%20(NAS,government%20and%20government%20aided%20schools.&text=The%20learning%20levels%20of%202.2,36%20States%2FUTs%20were%20assessed.

SLR provides information on the following points:

- Class-wise participation of students/teachers and school principals in the survey.
- Average State/UT achievement by classes and subjects against the National Achievement.
- Distribution of students in different achievement levels (0–30%, 30–50%, 50–75%, above 75%) by classes and by subjects.
- Disaggregated performance in terms of gender, location, management, and social groups.
- Students' perceptions about coming to school, difficulty faced in travelling to school, understand what the teacher says in the class, etc.
- Teachers' responses to a few aspects of schools and schooling such as infrastructure; availability of instructional material; classroom assessment practices and parental involvement, etc. (school and teacher questionnaires).
- A composite score to indicate the average performance of a district across classes and subjects.
- Performance of the LOs in the state.

All the results in the SLRs were computed using the Classical Test Theory (CTT) and reported through percentages.

National Report to Inform Policy, Practices and Teaching-learning

National Report to Inform Policy, Practices and Teaching-learning is meant for reference of researchers, assessment specialists with existing technical understanding of assessments and in large scale quantitative data sets.

This report provides information on the following aspects of the assessment:

- Assessment framework and NAS tools (tests and questionnaires)
- Psychometric analysis of the test items
- Sampling design and detailed procedures
- Procedures followed, including field operations, data analysis and limitations
- Descriptions of student achievement in scale scores using IRT, including differences between subgroups
- Representation of achievement in scale scores using IRT
- Computation of achievement proficiency bands
- Association of Background Variables that correlate against achievement
- Achievement shown against proficiency

bands

NAS Mobile Application

A user-friendly mobile application for NAS 2017 was also developed. The application enabled users to run queries on the NAS 2017 data and visualise the reported data in the form of maps, charts and tables. The mobile application is available on the android platform.

NAS Results for Policy Implications

Performance of States/UTs in Class III

Analysis of the data showed that the performance of Class III students in the learning outcomes of language is low in the States of Arunachal Pradesh, Lakshadweep, Uttar Pradesh, Puducherry and Delhi. In mathematics, the performance was lower than the national average in the States of Arunachal Pradesh, Delhi, Punjab, Meghalaya, and Haryana. Performance in the learning outcomes of Environmental Studies was low in the States of Arunachal Pradesh, Lakshadweep, Uttar Pradesh, Delhi, and Sikkim. Overall, the performance of the students in mathematics was found to be lower as compared to the other subjects. States/UTs in which ST students performed better than other social groups in languages were Nagaland, Manipur, and Tamil Nadu. States/UTs in which SC students performed better than general category students in languages were Manipur, Karnataka, and Tamil Nadu. States/UTs in which ST students performed better than other social groups in mathematics were Delhi, Arunachal Pradesh, Nagaland, and Manipur. States/UTs in which ST students performed better than other social groups in EVS were Delhi, Arunachal Pradesh, and Manipur. Performance of the rural students in the learning outcomes of language was found to be higher in the following States: Andhra Pradesh, Karnataka, Uttarakhand, Nagaland, and Maharashtra. Performance of the rural students in the learning outcomes of mathematics was found to be higher in the following States: Karnataka, Andhra Pradesh, Uttarakhand, Maharashtra, and Himachal Pradesh. Performance of the rural students in the learning outcomes of EVS was found to be higher in the following States: Karnataka, Andhra Pradesh, Uttarakhand, Maharashtra, and Himachal Pradesh.

Some of the low performing learning outcomes (LOs) in the States/UTs were:

Language

- Reads small text with comprehension, i.e., identifies main ideas, details, sequence and draws conclusion.

Mathematics

- Fills a given region leaving no gaps using a tile of a given shape.
- Extends patterns in simple shapes and numbers.

Environmental Studies

- Observes rules in games (local, indoor, outdoor).
- Records observations, experiences, information on objects/activities/places visited.
- Identifies simple features of animals and birds in the immediate surroundings.

Performance of States/UTs in Class V

Performance in the learning outcomes of

language is low in the States of Arunachal Pradesh, Meghalaya, Sikkim, Uttar Pradesh, and Puducherry. In mathematics, States in which the performance was low were Arunachal Pradesh, Sikkim, Meghalaya, Delhi, and Daman and Diu. Performance in the learning outcomes of Environmental Studies was found to be low in the States of Arunachal Pradesh, Sikkim, Meghalaya, Lakshadweep, and Daman and Diu. Performance of the girls in the learning outcomes of language was found to be higher in the following States: Kerala, Karnataka, Maharashtra, Gujarat, and Jharkhand. In mathematics girls performed better in the States of Karnataka, Jharkhand, Gujarat, Maharashtra, and Tamil Nadu. While in EVS, the girls were ahead in the States of Kerala, Karnataka, Jharkhand, Assam, and Gujarat. Performance of the rural students in the learning outcomes of language was found to be higher in the States of Kerala, Karnataka, Maharashtra, Nagaland and Chhattisgarh. While performance of the rural students in the learning outcomes of mathematics was found to be higher in the States of Karnataka, Kerala, Assam, Uttarakhand, and Delhi. In EVS, the rural students did better in the States of Kerala, Karnataka, Uttarakhand, Assam, and Odisha.

Some of the low performing learning outcomes (LOs) in the States/UTs were:

Language

- Reads and comprehends independently story books, news items/headlines, advertisements, etc.

Mathematics

- Estimates the volume of a solid body in known units.
- Identifies and forms equivalent fraction of a given fraction.
- Applies operations of numbers in daily life situations.

Environmental Studies

- Establishes linkages among terrain, climate resources (food, water, shelter, livelihood) and cultural life (example, life in distant/difficult areas like hot/cold deserts).
- Groups objects, materials, activities for features/properties such as shape, taste, colour, texture, sounds, traits, etc.
- Guesses (properties, conditions of phenomena), estimates spatial quantities (distance, area, volume, weight) and time in simple standard units and verifies using simple tools/setups.

Performance of States/UTs in Class VIII

Performance in the learning outcomes of language is low in the States of Nagaland, Jammu and Kashmir, Puducherry, Arunachal Pradesh, and Mizoram. In mathematics the States of Puducherry, Sikkim, Daman and Diu, Punjab, and Delhi performed lower than the average performance of the nation as a whole. The States/UTs whose performance in sciences is low are Puducherry, Lakshadweep, Nagaland, Daman and Diu, and Delhi. Performance of Social Science is low in Puducherry, Lakshadweep, Tamil Nadu, Mizoram, and Daman and Diu. In languages, in the State of Gujarat, Kerala, Maharashtra, Karnataka and Chandigarh girls performed better than the boys. In

mathematics, the States in which girls did better were Jharkhand, Karnataka, Gujarat, Madhya Pradesh, and Maharashtra. In the States of Karnataka, Gujarat, Andhra Pradesh, and Tamil Nadu, girls did better than the boys in sciences. Performance of the girls in the learning outcomes of social science was found to be higher in the States/UTs of Gujarat, Chandigarh, Karnataka, Andhra Pradesh, and Haryana. Performance of the rural students in the learning outcomes of language was found to be higher in the States/UTs of Gujarat, Chandigarh, Karnataka, Uttarakhand, and Andhra Pradesh. Learning outcomes of mathematics was found to be higher in the States of Rajasthan, Jharkhand, Karnataka, Andhra Pradesh, and Gujarat. Rural students did better in science than their urban counterparts in the States of Rajasthan, Karnataka, Jharkhand, Gujarat and Andhra Pradesh. Achievement of the learning outcome of social science was found to be higher for the rural students in the States of Rajasthan, Gujarat, Jharkhand, Karnataka and Andhra Pradesh.

Some of the low performing learning outcomes (LOs) in the States/UTs were:

Language

- Reads textual/non-textual material with comprehension and identifies the details, characters, main idea, and sequence of ideas and events while reading.

Mathematics

- Finds surface area and volume of cuboidal and cylindrical objects.
- Generalises properties of addition and subtraction, multiplication and division.
- Finds out approximate area of closed shapes by using units, square grid/graph.
- Solves problems related to conversion of percentage to fraction and decimals and vice versa.
- Arranges given/collected information in the form of table, pictograph and bar graph and interprets them.
- Uses exponential form of numbers to simplify problems involving multiplication and division of large numbers.

Science

- Understands simple investigation to seek answers to queries.
- Explains processes and phenomenon.

Social Science

- Describes the functioning of rural and urban local government bodies in sectors like health and education.
- Analyses the decline of pre-existing urban centres and handicraft industries and the development of new urban centres and industries in India during the colonial period.
- Locates important historical sites, places on outline map of India.
- Locates distribution of important minerals, e.g., coal and mineral oil on the world map.
- Draws interrelationship between types of farming and development in different regions of the world.
- Applies the knowledge of the

fundamental rights to find out about their violation, protection and promotion in each situation.

- Identifies the role of government in providing public facilities such as water, sanitation, road, electricity, etc., and recognises their availability.

Discussion and Conclusion

In India, NAS presents a system level reflection on effectiveness of school education in the country. NAS is embedded in a rich system of background variables. These variables help to contextualise the achievement of the students. The synthesis of the results at the national level becomes a unique source for the development of Indian education system. The sample for NAS is drawn from all government and government aided schools. Inclusion of all those in the government set up majorly helps to understand the delivery of the system. Also, in the near future, it is envisaged to broaden the sample framework of NAS to include the private schools as well.

Given India's present situation, it may not be possible to emulate the examples of the developed countries such as Finland and Singapore and to do away totally with the national large-scale assessment focusing only on school-based assessment. Though the practices being followed in such developed countries should be the ultimate goal, at present a blended environment which has both, will be more appropriate. The argument towards a blended approach is crystallised by the Performance Grading Index (PGI) of the Department of School Education and Literacy, MoE, wherein all 36 States and UTs are at different levels. While a lot still needs to be done, the good news is that some states and UTs, such as Karnataka, Rajasthan, Kerala, Gujarat and Chandigarh, etc., are excellently positioned to reach the standards in school education which are comparable to those in the developed countries. In these states and UTs, therefore, it would be admissible to focus on School Based Assessment (SBA) along with intensive training of teachers vis-à-vis those where a more autocratic learning assessment would be desirable. It is expected that the initiatives of the Department of School Education and Literacy, i.e., PGI, and SBA together will create a situation for learning outcomes to improve through a sustainable methodology.

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UTILISATION OF INNOVATIVE TECHNOLOGY TOWARDS A HUMAN-CENTRED FUTURE SOCIETY

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India views technology and digitisation as essential tools to advance towards a scenario in which citizens and the challenges they encounter are placed at the centre of technological innovation, solution development, and service delivery. With a firm foundation of digital infrastructure and expanded digital access through Digital India Programme, India is now poised for the next phase of growth, creating tremendous economic value and empowering citizens as new technological applications permeate every sector. India has successfully leveraged the amalgamation of various platforms, such as PMJDY, AADHAAR, mobile phones (Mobile) and their links with public cloud (Meghraj), Digilocker, UPI/BHIM, AEPS, JAM. In addition, digital transformation in India has successfully bridged the gender divide by increasing women inclusion in employment, school enrolment for girls, admission in BPO training programmes and in supporting women entrepreneurs and self-help groups for showcasing their products and services, therefore catalysing numerous opportunities for women. This article sheds light on such initiatives and their benefits and discusses overall utilisation of innovative technology towards a human-centred future society.

Keywords: Innovative technology, Human-centred future society, Digital India, BPO, Digital infrastructure Jan-Dhan-Aadhar-mobile (JAM)

Introduction

A human-centred society is one that balances economic advancement with the resolution of social problems by a system that integrates cyberspace and physical space. We are now in a new era, one in which innovation driven by enabling technologies such as Internet of Things (IoT), Artificial Intelligence (AI) and robotics are bringing significant changes to the economy and society. Frontier technologies such as AI, blockchain, machine learning are gathering traction as penetration of the internet and smartphones is increasing. They are seen as essential tools to bridge gaps in the existing social service delivery mechanisms and thus improve the quality of life for citizens. Leveraging these technologies will provide advanced solutions to some of the biggest global challenges.

Artificial Intelligence for Human-Centred Future Society

The Artificial Intelligence (AI) is a way of making a computer, a computer-controlled robot, or a software think intelligently, in a similar manner that humans think. AI is accomplished by studying how human brain thinks, and how humans learn, decide, and work while trying to solve a problem, and then using the outcomes of this study as a basis of developing intelligent software and systems. Innovative technology relating to AI such as Machine Learning, Data Analytics, etc., are evolving and they can be very useful to improve services delivery in government and private sectors. An essential requirement for development of such technologies is availability of large volume of data on which the AI engines can work and thereafter develop applications.

India's national strategy for AI, titled **#AIforAll,** prioritises the development of AI solutions to solve challenges faced in social sectors such as agriculture, education, health, mobility' and infrastructure. The strategy addresses the present gaps in research and development in AI' by proposing the establishment of domain specific Centres of Research Excellences (COREs) and International Centres for Transformation (ICTAIs) for foundational research and development of market ready AI solutions in these sectors. The ICTAIs are proposed to facilitate the close interaction of AI experts with social sectors domain experts, and industry to create market ready products to solve societal challenges.

One of the significant recommendations of the strategy is the **'AI for ALL' Alliance** – a global platform for collaboration to promote inclusive AI and follow joint projects in the AI. This multi-disciplinary multi-national research collaboration has garnered special interest internationally. The Alliance is expected to pursue pushing the technology frontier (viz., explainable AI, addressing biases) and democratising the application of AI, i.e., change the narrative from autonomous vehicles to solving access, affordability and availability of eminent healthcare, education, sanitation and essential resources. The Government of India is keen on exploring collaborations with like-minded countries as founding partners for the AI for All Alliance.

Blockchain Technology

With data collection and analysis, audit trail mechanisms are concerned about data security and privacy. The conventional solution to have a centralised, trusted party to host the data on behalf of data providers is not always practical. The data providers do not encourage replication of data that not only raises trust concerns but also adds to costing and control issues. A more effective method to address these concerns is a decentralised data marketplace that is based on blockchain technology.

The research projects are being undertaken by the Government of India to explore the efficiency and effectiveness of blockchain technology. There are varied uses of the blockchain technology such as it can be used in land registry system which expedite land and property registrations and enable a corruption and middlemen-free system of smart transactions. In healthcare, research is being done to explore if block chain can be implemented in supply chain management to trace drugs protecting citizens from fraudulent drugs. In agriculture, blockchain based supply chain system is being explored to allow audit trails for fertiliser sale to farmers authenticating the supply in a secure manner. The research in blockchain technology provides a decentralised and transparent environment resolving mistrust issues. The blockchain technology is being explored in a variety of sectors such as healthcare, agriculture and infrastructure.

Initiatives towards a Technologically Enabled Society in India

It is now globally accepted that in the 21st century digitalisation has emerged as an important driver for socio-economic growth impacting all significant economic sectors. For India, digitalisation provides an unprecedented opportunity to meet the aspirations of more than 1.2 billion citizens in a transparent, inclusive, sustainable, efficient and cost effective manner. In India, digital

economy is projected to reach US$ 1 trillion by 2025.

Digital India Programme: An Approach towards Human-centred Future Society

The Digital India programme of the Government of India is an umbrella programme that is intended to transform India into a knowledge-based economy and a technologically empowered society by ensuring digital services, digital access, bridging the digital divide, digital inclusion and digital empowerment. Such an aim is sought to be achieved with the power of technology that is affordable, developmental and inclusive.

The Digital India architecture has been significantly using innovative technology. It has transformed governance processes for delivery of services. The Digital India weaves together a large number of ideas and thoughts into a single comprehensive vision to ensure that benefits of development reach each and every citizen of the country in equal measure along with the need for faster and timely service delivery. This dream is centred on Digital Identity, Digital Infrastructure, Digital Literacy and Skilling, Digital Delivery of Services, Digital Payment, Digital Entrepreneurship and Industry and Cyber security. One of the key dream areas of the Digital India Programme is ensuring Digital Infrastructure as a centre utility to every citizen. Recognising that robust digital infrastructure from the foundation of Digital India, various specific initiatives have been undertaken towards the development of Digital Infrastructure in the country such as Jan dhan-Aadhaar-Mobile (JAM) trinity, Bharat Net, NKN, MeghRaj, Common Service Centres, etc.

The rapid stride taken in digitalising administration during last five years have brought India to a stage where outside world is keen to learn from our experience. More than 2300 services are already available on digital platform. The Government of India has taken numerous initiatives in this direction to utilise innovative technology. The government simultaneously deploys technology for improving governance and make growth more inclusive and sustainable. In India, the initiatives in this direction should be seen beyond IT and governance aimed at empowering ordinary people with an objective to make people use digitally innovative technology with the target of bridging of rural-urban gaps. It is also ensuring that the national efforts to bring about transparency in governance are reached.

India's Experience with Digital Platforms

India's national digital platforms are founded on four core principles: that digital services should be capable of being authenticated from anywhere, 'paperless' or reliant on digital records, 'cashless' or truly universalising the access and usage of digital payments, and 'consent-based' or allowing secure movement of data authenticated by its owners. It is based on the realisation that digital technologies have the potential to impact all sectors of economy, be it education, health, agriculture or infrastructure. Platform based digital technologies are. Transformative and are able to deliver desired outcomes at a pace unimaginable. Traditionally, while ushering in larger transparency in governance, and promoting economic and social inclusion.

India has successfully leveraged the amalgamation of various platforms such

as digitally enabled bank accounts *Pradhan Mantri Jan Dhan Yojana* (PMJDY), which is the world's largest financial inclusion programme, unique digital identity (AADHAAR), mobile phones (Mobile) and their links with public cloud (Meghraj), document exchange platform (Digilocker), Unified Payment Interface/Bharat Interface for Money (UPI/ BHIM), Aadhaar Enabled Payment Systems (AEPS), *Jandhan-Aadhaar-Mobile* (JAM), etc. More prominently, such free and open infrastructure service is available to even the smallest entrepreneurs. It has opened up a window of opportunities to innovate and fulfil demands of the demographically diverse Indians. It ushered a new social revolution in India. It has provided the enabling ecosystem to transform governance through a model that is unique globally in terms of sheer size, scale and innovation. Further, from inclusion perspective, as part of *PradhanMantri Jan DhanYojna*: PMJDY (Prime Minister's Peoples' Wealth Scheme), 373 million beneficiaries were provided bank accounts, enabling the beneficiaries to receive various social security benefits directly into their bank accounts. Thus, it is ensuring efficiency and transparency.

India is set to leapfrog in digital payments bypassing the era of cards. Net banking which is reflected through number of such transactions growing by more than 100 per cent in last one year. One of the building blocks of the payments ecosystem in India, Unified Payments Interface (UPI) powers multiple bank accounts into a single mobile application (of any participating bank), merging several banking features, seamless fund routing and merchant payments into one hood. Based on UPI, India has built Bharat Interface for Money (BHIM) application, which allows users to directly perform payment transfers to other users or merchants with an easy to use interface. The transactions on BHIM-UPI have grown exponentially. The BHIM has been downloaded 51.59 million times since its launch in December 2016. The number of transactions on BHIM-UPI platforms (BHIM and BHIM-UPI family Apps) with 31.83 million per day, has reached US$23.07 billion and 955 million (by volume) upto September 2019. While the overall digital transactions have reached nearly 30.13 billion in the financial year 2018–19 with annual growth of 51 per cent by volume and 19 per cent by value.

For a digitally inclusive society, more than 3,63,980 Common Service Centres (CSCs) as Digital kiosks have been set up in over 2,62,654 Gram Panchayats. Digital kiosks have created entrepreneurial opportunities for one million village-level entrepreneurs, including 37,144 women entrepreneurs with a view to provide more than 350+ different services to citizens in urban as well as rural areas as on 30 September, 2019. Basic computerisation of land records has also been completed in majority of States. It paves the way for a more digitised, transparent, and efficient property-related services.

A Government e-Marketplace (GeM) has been set up to facilitate online procurement of common use goods and services required by various government departments/ organisations/PSUs. The GeM aims to enhance transparency, efficiency and speed in public procurement. It provides the tools of e-bidding, reverse e-auction and demand aggregation to facilitate the government users, achieve the best value for their money. The GeM attempts to address price inefficiencies in public procurement by

increasing transparency through an online platform for sourcing. A similar initiative, the e-NAM (e-National Agriculture Market) now brings more farmers closer to the market obviating the need for middlemen.

In India, the digital transformation has successfully bridged the digital gender divide. In addition to 37,144 functional women village level entrepreneurs (VLEs), the Information Technology Enabled Services (IT-ITES) industry in our country employs around 4.14 million workers of which 30 per cent are women. A three-year awareness programme in rural India on the opportunities in the BPO industry enhanced women's enrolment in Business Process Outsourcing (BPO) training programmes. It also increased school enrolment among young girls by 3-5 per cent. Numerous other initiatives of the Government of India like Mahila E-HAAT, a bilingual direct online marketing platform leveraging technology for supporting women entrepreneurs and self-help groups for showcasing their products and services, has leveraged numerous opportunities and gainful employment for women.

Through Aadhaar, the Government of India has provided digital identity to 1.24 billion residents of the country with 99 per cent coverage of adult population as on date. Earlier, a substantial percentage of population, especially the economically poor and the rural segment, women and children, did not have an identity card by which they could access a service. Aadhaar has given individuals a government issued ID card which can be authenticated any time anywhere. Aadhaar combined with Digital Locker, eSign, and various forms of digital payments have paved the way for common men getting services on their mobile instead of having to run to multiple offices.

The direct employment in the IT services and BPO/ITeS segment is expected to grow over 4.3 per cent and add around 1,72,000 employees during the year 2018–19 reaching a total of 4.14 million, which is an important achievement for the sector. The skills profile in the industry is set to undergo a rapid change as demand for skills around digital technologies grows exponentially in the wake of new technologies and digitisation initiatives of the Government of India.

India continues its thrust of being one of the most vibrant landscape for start-ups, strengthening its position as the second largest startup ecosystem across the globe. In 2018, adding over 1,800 technology start-ups, India is witnessing a rapid rise in the tech start-ups, reaching more than 8,000 focused on verticals like healthcare, fintech, and e-commerce/aggregators. The Government of India has taken a number of steps to boosting startup ecosystem. Startup India is a flagship initiative of the Government of India. It intended to build a strong eco-system for nurturing innovation and startups in the country that will drive sustainable economic growth. It also generates large scale employment opportunities. The Ministry of Electronics and Information Technology (MeitY) has also taken various initiatives to improve innovation-led ecosystem with a technology incubation. The initiatives also include Technology Incubation and Development of Entrepreneurs (TIDE) scheme, Centres of Excellence in IoT/ FinTech space, technology and theme based incubation centres and programmes to support researchers, start-ups and Micro,

Small and Medium Enterprises (MSMEs) protect IPRs nationally and internationally. The MeitY is going to launch an enhanced version of TIDE, i.e., TIDE 2.0 scheme to promote technology incubation.

In order to facilitate government's dream of promoting technology innovation, start-ups and creation of Intellectual Properties, a nodal entity called 'MeitY Start-up Hub' (MSH) has been setup under its aegis. The MSH will act as a national coordination, facilitation and monitoring centre that will integrate all the incubation centres, start-ups and innovation related activities of MeitY. Our government has also approved the National Policy on Software Products, 2019. It will incentivise industry to move up the value chain, from services to products. It partly reduces the risk in such product development as India's digital consumer base is the second largest in the globe and growing at the second-fastest rate amongst major economies. India's inclusive digital model is narrowing the digital divide within the country. It brings benefits of technology to all segments of people of the country.

Conclusion

Human-centred future society goals at a super smart society which keeps digitisation at its centre and leverages innovative technology to its fullest in the service of the people.Initiatives under the Digital India programme focusing towards digital inclusion, bridging the gender divide by increasing women inclusion in employment, thus increasing the landscape of ICT to impact 1.2 billion Indians. It has now started showing resonance among the common masses. India's success in utilisation of digital technology and platforms is a model for other developing nations to emulate. It helps to move towards sustainable and inclusive human-centred society.

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CLIMATE CHANGE : A GLOBAL PHENOMENA

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Increasing world population and the increasing desire of human beings to raise their standard of living has led to technological innovations of all kinds. These innovations have made life more comfortable but at the cost of increased demands for food, air, water, minerals and energy. Rapid depletion of natural resources all around us has caused unprecedented changes in global climate resulting in serious implications on the survival of both human and animal species on earth. It is feared that one-fourth of earth's species could be headed for extinction by 2050. We should emphasise to use renewable sources of energy like wind, solar, biomass and ocean geothermal energy.

Key Words: IPCC-I, NSF, Climate change, Global warming

Introduction

Climate change means a long term change in earth's climate due to natural, mechanical and anthropological processes which result in the emission of greenhouse gases like CO_2, methane, etc.

Our planet earth has witnessed many changes in climate since the beginning. Geological records also show alternation of glacial and interglacial periods. The geomorphological features in high altitudes and high latitudes, exhibit traces of advances and retreats of glaciers. Deposition of sediment in glacial lakes also proves the occurrence of warm and cold periods. The sign of rings in the trees also provide clues about wet and dry periods. These proofs show that change in climate is a natural and continuous process. India also witnessed alternate wet and dry periods. Archaeological research shows that the Rajasthan desert experienced wet and cool climate around 8,000 B.C. The period 3,000-1,700 B.C. had higher rainfall. From about 2,000-1,700 B.C., this region was the centre of Harappa civilisation. Dry condition accentuated since then.

Variability in climate occurs all the time. But the 9th decade of the twentieth century witnessed extreme weather events. The 1990s recorded the warmest temperature and worst floods around the world. The worst devastating drought in the Sahel region, south of Sahara desert, from 1967–1977 is one such variability. During the 1930s, a severe drought occurred in south-western Great Plains of the United States, described as the dust bowl.

Migration of people and crop yield or crop failures, of floods, also tell about the effects of changing climate. Europe faced many times warm, wet, cold and dry period, the significant episodes were the warm and dry conditions in the 10th and 11th centuries, when the Vikings settled in Greenland. Europe had 'Little Ice Age' from 1550 to about 1850. World temperature showed an upward trend during 1885–1940. The rate of increase in temperature slowed down after 1940.

Global Trends in Climate Change

Earth's climate continuously changed. In the last 650,000 years, there have been seven cycles of glacial advance and retreat. The

surface of the earth's temperature has risen about 1.62 degrees due to increased carbon dioxide and other human-made emissions into the atmosphere. The current warming trend is the result of human activity since the mid-20th century. United Nation's Intergovernmental Panel on Climate Change (IPCC-I) emphasises that increasing the use of coal and oil to fuel a worldwide consumer society will make the process of climate change rapidly worse. Burning of fossil fuels like coal, oil and clearing of land for human activities also increased concentrations of greenhouse gases.

Satellites and other technological advances reveal the signals of our climate changes. Tropical mountain glacier, Antarctica and Greenland show the earth's climate responding to changes in greenhouse gas levels. Ancient evidence shows that current warming is occurring roughly ten times faster than the average rate of ice age recovery warming. NASA's Gravity Recovery and Climate Experiment data show that Greenland lost an average of 286 billion tons of ice and Antarctica lost about 127 billion tons of ice per year between 1993 and 2016.

Satellite observation show glaciers of Himalayas, Andes, Rockies, Alps, Alaska and Africa are retreating and extent and thickness of Arctic sea ice have declined rapidly over the last several decades. A study reveals that 2 billion tons of carbon dioxide is absorbed by the upper layer of the oceans per year.

According to researchers of Ohio State University, USA glaciers and ice caps around the world are melting and retreating for over two decades. This will reduce hydroelectric power production, crop irrigation and drinking water supply in the region.

The greenhouse effect not only destroys the world's freshwater reservoirs but also projected to cause floods and droughts, reduce the area of arable land, adversely impact fish and food stocks, erode coastlines as sea levels rise and trigger the large movement of population to safer areas. This will lead to large scale migration and competition for resources.

National Climate Data Centre (NCDC) and the National Science Foundation (NSF) reveal that global warming has contributed to the emergence of stronger hurricanes in the Atlantic ocean.

The report of the International Panel on Climate Change (IPCC) has made it clear that climate change is happening largely because of human activity.

Causes of Climate Change

There are many causes responsible for climate change. But we can divide them into astronomical and terrestrial causes. In the astronomical causes, we saw changes in solar output associated with sunspot activities. Sunspots are also playing a major role in climate change. Some meteorologists agree that when there is increase in the number of sunspots, we feel cooler and wetter weather and but greater storminess occur.

Volcanism is also a major cause of climate change. Volcanoes discharge a lot of aerosols into the atmosphere.These aerosols remain in the atmosphere for a considerable period of time reducing the sun's radiation reaching the earth's surface. The most important anthropogenic effect on the climate is the increasing trend in the concentration of greenhouse gases in the atmosphere which is the cause of global warming.

Outcomes of Climate Change

The main outcomes of climate change are:

1. Global Warming (Green House Effect)
2. Acid Rain
3. Ozone layer depletion

Global Warming (Greenhouse Effect)

Global warming is a gradual increase in the overall temperature of the earth's atmosphere. It is generally attributed to the greenhouse effect caused by increased levels of CO2, methane (CH4) and other harmful gases in the atmosphere.

Some sunlight that hits the earth is reflected back into space while the rest warms the earth. But increased level of greenhouse gases (CO2, CH4, N2O) prevent heat from escaping into space, warming the earth move.

Carbon dioxide is responsible for climate change; it is released through volcano eruptions and human activities such as deforestation, land-use changes and burning fuels. Methane (CH4) is an active greenhouse gas and produced through natural sources and human activities including the decomposition of wastes and agriculture.

Nitrous oxide (N2O) is an important greenhouse gas released by soil cultivation practices, especially the use of commercial and organic fertilisers, fossil fuel combustion and biomass burning.

Chlorofluorocarbons (CFCs) are also greenhouse gases. They are products of human activity. Ozone occurs in the stratosphere where ultraviolet rays convert oxygen into ozone thus ultraviolet rays do not reach the earth's surface. Chlorofluorocarbons drift into the stratosphere and destroy the ozone. Large depletion of ozone occurs over Antarctica.

The presence of greenhouse gases in the atmosphere is behaving like a greenhouse. The atmosphere transmits the incoming solar radiation but also absorbs the vast majority of long wave radiation emitted upwards by the earth's surface. The gases which absorb long wave radiation are called Greenhouse gases. The processes that warm the atmosphere are called the greenhouse effect.

Acid Rain

Normal rain drop is slightly acidic, with a pH of 5.6, while acid rain generally has a pH between 4.2 and 4.4. The main common cause of acid rain is air pollution. Mainly oxides of nitrogen and sulphur are responsible for acid rain. Oxides of sulphur and nitrogen react with water vapour present in the atmosphere and form sulphuric acid (H2SO4) and nitric acid (HNO3). Then, these come to the earth surface by rain. Acid rain creates a negative effect on human being, aquatic animals, plants, stones and other materials.

Ozone Layer Depletion

Ozone (O3) is the triatomic molecule of oxygen and it is a natural gas. O3 is present in both Troposphere and the Stratosphere.

Positive O3	Stratosphere	90% O3
Negative O3	Troposphere	10% O3

Tropospheric Ozone is negative for the living organisms because it creates pollution in the Troposphere, i.e. photochemical smog. While stratospheric Ozone is positive for us because it protects our earth surface from the ultraviolet radiation. Ultraviolet radiation has a wavelength from 100 nm - 400 nm, that is very harmful to the living organism.

Cause of Ozone Layer Depletion

Some gases like CFC – Chlorofluorocarbon, HCFC – Hydrochlorofluorocarbons and CCl4 – Carbon tetrachloride are mainly responsible for ozone layer depletion. From the gas chlorine molecule reacts with ozone and depletes it.

$Cl_2 \rightarrow Cl + Cl$ (2Cl)

$Cl + O_3 \rightarrow ClO + O_2$

$ClO \rightarrow Cl + O$

In this way, one chlorine atom depletes many O_3 molecules.

Impact of Climate Change in India

A large population of India depends upon agriculture, forest and fishery for livelihood. The impact of climate change in the form of increasing temperature and decreasing rainfall would create many problems in the country. The 15th Edition of Global Climate Risk Index 2020 found that about 2,081 deaths in 2018 in India were due to extreme weather events caused by climate change—cyclone, heavy rainfall, floods and landslides. These impacts can be discussed under the following headings:

- Drying Rivers

  Climate change is threatening the very existence of Himalayan glaciers. The Gangotri glacier, whose melted water feed the river Ganga has, for instance, been receding since 1780 but its rate of retreat has tripled in the last three decades. If this trend continues over the next 30 to 40 years, the Ganga could initially swell in volume because of increasing melting which could produce widespread flooding, rock avalanches from destabilised slopes and affected water resources within two or three decades, and when the river flow starts declining, Ganga and its tributaries could become a seasonal river.

- Agriculture and Food Security

  India's food security will be affected by climate change shortly. Indian agriculture depends on monsoon but the change in the precipitation pattern will reduce rice cultivation in Indo-Gangetic plains.

  Crop productivity will fall especially in non-irrigated lands as temperature rises by 1.2-degree centigrade on average by 2040 and greater crop loss of over 25 per cent as temperature rises to 5.4-degree centigrade by the end of this century. It means lower caloric intake for India's rural population. This grim situation indicates that the Indian government should give priority to better water management, new agricultural technology in a region-specific manner and evolve new cropping patterns which can tolerate higher temperature and water scarcity.

- Coastal Areas

  Climate change will raise sea level, which could inundate and erode coastal area, increase flooding and saltwater intrusion. Sea level will rise 40 cm higher by 2100 and 50 million people in coastal India will be displaced by flooding. It will affect coastal agriculture, fisheries and aquaculture, freshwater resources, human settlement and tourism. The state like Tamil Nadu can face increased frequency of coastal storm, higher mean temperature, more frequent drought and sudden flash flood.

- Human Health

  There is growing evidence that change in the global environment will have a profound effect on human health in India. Excessive monsoon rainfall and high humidity will enhance mosquito breeding. Scientists are concerned that

climate change can lead to an increase in temperature-related infections or diseases like malaria and kala-azar. Human health is also affected by cyclone, drought and heavy rainfall. Climate change will reduce food production which will lead to hunger and malnutrition.

- Forestry

  With erratic rainfall and decrease in precipitation levels, India's forest would deplete rapidly. The extreme temperature would extinct flora and fauna by 2030. According to R. Sukumar, an environmental scientist of Indian Institute of Science "Changes in temperature and rainfall associated with global warming could result in about 80 percent of existing forests in the country changing the type of vegetation". Climate change is rapidly becoming the most serious threat to the planet's biodiversity.

Conclusion

Climate change is a variable factor, it changes time to time from Human and Natural Activity to climate and culture, hence establishing close relationship. According to climate change culture automatically changes. Some harmful impacts of climate change are global warming, acid rain and ozone layer depletion. To sum up, it can be said that there is a need to change lifestyle and consumption pattern in all developed and developing countries. The world community should generate political consensus to mitigate greenhouse gases. Climate change is no longer an environmental issue but it is related to global security and survival. India must adopt new, energy-efficient technologies to reduce the CO_2 level. We should emphasise to use renewable sources of energy like wind, solar, biomass and ocean geothermal energy. In India collaborative action by government, the community and individuals could combat climate change.

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EFFECT ON THE VOLUME OF SOLVENTS AFTER DISSOLUTION OF SOLUTES

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The present paper deals with the change in volume of the solvent when a solid solute is dissolved into it. The results are presented with respect to the change of volume of solvent, the total volume of solvent and solute, and in terms of the molar concentration of solutions. Keywords: Solute, solvent. Solution, solvation, volume change, molar concentration

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Introduction

School Science Curriculum starts from the grouping of classifying objects on the various criteria at the middle stage. Solubility is one of the important criteria to group different materials into soluble and insoluble substances. The idea about the extent of dissolution of substances in water and formation of the saturated solution is also been discussed at this stage [NCERT 2006 A] When learner moves to the secondary stage particulate nature has been explained to them stating that in the liquids some spaces (intermolecular spaces) are available in which salt/sugar particles occupy the space when it is dissolved in them [NCERT 2006 B]. It also goes into the minds of students up to the secondary stage that when a pinch of a spoon of salt/sugar is added to a glass full of water, its volume does not change and the solute (salt/sugar) occupies the intermolecular spaces in the water so that there is no change in the volume. To make these things clearer efforts are made to explain that there will be a change of volume of solvent on dissolving solute into it.

Methodology

The data of densities of solid salt/ organic compounds and their 20 per cent w/w aqueous solutions were taken from the Chemical Engineer's Handbook [Mc Graw Hill 2008]. With the help of these data volume of the 20g of solid solute and volume of 80g water has been computed and presented in the Table-1.

Table 1: Basic data of densities and volumes of solute and solvent at the given temperature

S. No.	Name of Solute	Density of Solid Salt g/ mL	Amount of Solute (g)	Volume of the Solute (mL)	Amount of Solvent (water) (g)	Temperature °C	Density of Water	Volume of the Water (mL)	Density of 20% Aqueous Solution g/mL	Volume of 20% Aqueous Solution (mL)
	NaCl	2.16	20	9.259	80	25	0.9970470	80.237	1.14533	87.311
	KCl	1.98	20	10.101	80	25	0.9970470	80.237	1.13072	88.439
	NaNO3	2.26	20	8.849	80	20	0.9982067	80.144	1.14290	87.497
	NH4Cl	1.52	20	13.158	80	20	0.9982067	80.144	1.05670	94.634
	NH4NO3	1.72	20	11.628	80	20	0.9982067	80.144	1.08060	92.541
	CH3COONH4	1.17	20	17.094	80	20	0.9982067	80.144	1.03680	96.451
	CH3COONa	1.53	20	13.072	80	20	0.9982067	80.144	1.10210	90.736
	Na2SO4	2.66	20	7.519	80	20	0.9982067	80.144	1.19150	83.928
	Na2CO3	2.54	20	7.870	80	30	0.9956488	80.350	1.20860	82.740
	K2CO3	2.43	20	8.230	80	20	0.9982067	80.144	1.18980	84.048
	(NH4)2SO4	1.77	20	11.299	80	20	0.9982067	80.144	1.11540	89.654
	Sucrose	1.55	20	12.903	80	20	0.9982067	80.144	1.08100	92.507
	Urea	1.32	20	15.151	80	20	0.9982067	80.144	1.05300	94.967

Now with the help of the calculated volume of solvent (Water) and the Volume of the 20% w/w aqueous solution, an increase in the volume of solvent after the dissolution of solid solute is presented. An increase percentage in volume of solvent has also been computed and presented in Table 2

Table 2: Change in Volume after the dissolution of solute with reference to the solvent volume

S.No.	Name of Solute	Volume of Solvent (water) mL	Volume of Aqueous Solution (mL)	Increase in Volume (mL)	% Increase in Volume
		A	B	C = (B–A)	
	NaCl	80.237	87.311	7.074	8.82
	KCl	80.237	88.439	8.152	10.16
	NaNO3	80.144	87.497	7.353	9.17
	NH4Cl	80.144	94.634	14.490	18.08
	NH4NO3	80.144	92.541	12.397	15.47
	CH3COONH4	80.144	96.451	16.307	20.35
	CH3COONa	80.144	90.736	10592	13.22
	Na2SO4	80.144	83.928	3.784	4.72
	Na2CO3	80.350	82.740	2.390	2.97
	K2CO3	80.144	84.048	3.904	4.87
	(NH4)2SO4	80.144	89.654	9.510	11.87
	Sucrose	80.144	92.507	12.363	15.42
	Urea	80.144	94.967	14.823	18.49

Efforts have also been to calculate the change in volume of the solution with reference to a total volume that includes the volume of solid solute and of liquid solvent. Calculated data is presented in Table 3.

Table 3: Change in volume of the solution with reference to total volume of the mixture

S. No.	Name of Solute	Volume of the Solid solute (mL)	Volume of the water (mL)	Total volume of mixture before recitation (mL)	Volume of the Aqueous Solution (mL)	Change in Volume (mL)	Change in vol. in %
				A	B	C = (B – A)	
	NaCl	9.253	80.237	89.996	87.311	– 2.187	– 2.44
	KCl	10.101	80.237	90.338	88.439	– 1.899	– 2.10

	NaNO3	8.849	80.144	88.993	87.497	– 1.496	– 1.68
	NH4Cl	13.158	80.144	93.302	94.634	+ 1.332	+1.43
	NH4NO3	11.628	80.144	91.772	92.541	+ 0.769	+ 0.84
	CH3COONH4	17.094	80.144	97.238	96.451	– 0.787	– 0.81
	CH3COONa	13.072	80.144	93.216	90.736	– 2.48	– 2.66
	Na2SO4	7.519	80.144	87.663	83.928	– 3.735	– 4.26
	Na2CO3	7.870	80.350	88.220	82.740	– 5.480	– 6.21
	K2CO3	8.230	80.144	88.374	84.048	– 4.326	– 4.89
	(NH4)2 SO4	11.299	80.144	91.443	89.654	– 1.789	– 1.96
	Sucrose	12.903	80.144	93.047	92.507	– 0.540	– 0.58
	Urea	15.151	80.144	95.295	94.967	– 0.328	– 0.35

In order to have clear picture on the basis of molar concentration, the calculations were also made to find out the percentage change in volume with respect to volume of solvent and total volume of mixture of solute and solvent. The calculated values are presented in Table-4.

Table 4: Change in volume with reference to molar concentration (0.001M)

S. No.	Name of Solute	Mass of Solute taken (g)	Formula/ Molar Mass solute g/mol	Molar Amount	% change in vol. wrt volume of mixture per mili mole (0.001M) of solute	% increase in vol. wrt volume of solvent per mili mole (0.001M) of solute
1.	NaCl	20	58.44	0.342	0.71 (–)	2.58
2.	KCl	20	74.55	0.268	0.78 (–)	3.79
3.	NaNO3	20	84.99	0.235	0.71 (–)	3.90
4.	NH4Cl	20	53.49	0.374	0.38 (+)	4.83
5.	NH4CO3	20	96.09	0.208	0.40 (+)	8.69
6.	CH3COONH4	20	77.08	0.259	0.31 (–)	5.97
7.	CH3COONa	20	82.03	0.244	0.11 (–)	8.34
8.	Na2SO4	20	142.04	0.141	3.02 (–)	2.63
9.	Na2CO3	20	105.98	0.189	3.28 (–)	2.50
10.	K_2CO_3	20	138.20	0.145	3.37 (–)	2.05

SO^{2-}

11.	$(NH_4)_2 SO_4$	20	132.14	0.151	1.30 (–)	3.22
12.	Sucrose	20	342.30	0.058	1.00 (–)	20.46
13.	Urea	20	60.60	0.330	0.11 (–)	05.60

Result and Discussion

Data presented in Tables 1 and 2 show that the all the solutes under the study whether ionic or non-ionic, increase the volume of solvent on dissolving 20 per cent by mass of it. The highest increase is observed in the case of CH_3COONH_4 and lowest in the case of Na_2CO_3. This indicates that the solute particles (ions or molecules) do not fit completely in the intermolecular spaces present in the solvent (water). The amount of increase in volume of solvent on dissolving any solute depends on solute-solvent interaction, the size of ions/ molecules, charge, hydration of solute particles [Pederson and Hvidt Aase, 1985] percent increase in volume data of NaCl, KCl, Na_2CO_3 and K_2CO_3 and K_2CO_3 solutes clearly indicate that the size of K^+ is more than Na^+ ions. Similarly, data of Na_2SO_4 and Na_2CO_3 shows that size of SO_4^{2-} ion is larger than CO_3^{2-} ion. These inferences are of pedagogical importance that in some cases learners can be given exercises to compare the cationic or anion sizes by measuring and comparing the volumes of their appropriate salts.

In Table 3 data presents the change in volume with reference to the total volume of mixture (solute solvent). All the solutes under study show decrease in volume except NH_4Cl and NH_4NO_3 where the volume increase by 1.43 per cent and 0.84 per cent respectively. The observations from Tables 1, 2 and 3 show that all the cations, anions and organic molecules increase the volume of solvent and decrease the volume with respect to total volume of mixture of solute and solvent except NH_4^+ ions. It means most the ions and organic molecules have tendency to decrease the volume of mixture of solute and solvents that may be termed as shrinkage effect. In case of NH_4Cl and NH_4NO_3, the increase in volume of solution in observed with respect to total volume of solute and solvent. This swelling effect may be due to bifurcated hydrogen bonding formed by NH_4^+ ion in the solution [Guo J et al, 2018 and Hollas D et al, 2017] similar to the hydrogen bond formation in water when it is converted into ice leading to swell in volume of system. However, in case of CH_3COONH_4 and $(NH_4)_2SO_4$ there is decrease in volume. This observation indicates that shrinkage effect of CH_3COO^- and ions predominate over the swelling effect of ions in these salt solutions.

Conclusion

It may be concluded that on dissolving most of the solute decreases the volume of solutions with respect to the total volume of solute and solvent. Some ammonium salts show opposite effect.

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SCIENCE NEWS

Capturing the Energy of Slow Motion

A new concept in energy harvesting could capture energy that is currently mostly wasted due to its characteristic low frequency and use it to power next-generation electronic devices. In a project funded by electronics giant Samsung, a team of Penn State materials scientists and electrical engineers has designed a mechanical energy transducer based on flexible organic ionic diodes that points toward a new direction in scalable energy harvesting of unused mechanical energy in the environment, including wind, ocean waves and human motion.

Devices to harvest ambient mechanical energy to convert to electricity are widely used to power wearable electronics, biomedical devices and the so-called Internet of Things (IoT) — everyday objects that wirelessly connect to the internet. The most common of these devices, based on the piezoelectric effect, operate most efficiently at high frequency, greater than 10 vibrations per second. But at lower frequencies their performance falls off dramatically.

"Our concept is to specifically design a way to turn low-frequency motion, such as human movement or ocean waves, into electricity," said *Qing Wang*, professor of materials science and engineering, Penn State. "That's why we came up with this organic polymer p-n junction device."

Called an ionic diode, their device is composed of two nanocomposite electrodes with oppositely charged mobile ions separated by a polycarbonate membrane. The electrodes are a polymeric matrix filled with carbon nanotubes and infused with ionic liquids. The nanotubes enhance the conductivity and mechanical strength of the electrodes. When a mechanical force is applied, the ions diffuse across the membrane, creating a continuous direct current. At the same time, a built-in potential that opposes ion diffusion is established until equilibrium is reached. The complete cycle operates at a frequency of one-tenth Hertz, or once every 10 seconds.

For smart phones, the mechanical energy involved in touching the screen could be converted into electricity that can be stored

in the battery. Other human motion could provide the energy to power a tablet or wearable device.

"Because the device is a polymer, it is both flexible and lightweight," Wang said. "When incorporated into a next-generation smart phone, we hope to provide 40 per cent of the energy required of the battery. With less demand on the battery, the safety issue should be resolved."

According to the authors on the paper "Flexible Ionic Devices for Low-Frequency Mechanical Energy Harvesting" published online in the journal *Advanced Energy Materials*, "The peak power density of our device is in general larger than or comparable to those of piezoelectric generators operated at their most efficient frequencies."

Michael Hickner, associate professor of materials science and engineering, produced the ionic polymers, with Liang Zhu, a postdoctoral scholar in his group. Qiming Zhang, distinguished professor of electrical engineering, and his group focused on device integration and performance. Wang's group, including coauthors postdoctoral scholar Qi Li and graduate student Yong Zhang, focused on materials optimisation. The co-lead authors are visiting scholar Ying Hou, recent Ph.D graduate Yue Zhou and visiting scholar Lu Yang, all part of Zhang's group.

"Right now, at low frequencies, no other device can outperform this one. That's why I think this concept is exciting," Wang said.

Climate Change Is already Causing Widespread Local Extinction in Plant and Animal Species

Extinctions related to climate change have already happened in hundreds of plant and animal species around the world. New research, to be published in the open-access journal *PLOS Biology,* shows that local extinctions have already occurred in 47 per cent of the 976 plant and animal species studied.

Climate change is predicted to threaten many species with extinction, but determining how species will respond in the future is difficult. Dozens of studies have already demonstrated that species are shifting their geographic ranges over time as the climate warms, towards cooler habitats at higher elevations and latitudes. The new study, by Professor John J. Wiens from the University of Arizona, used these range-shift studies to show that local extinctions have already happened in the warmest parts of the ranges of more than 450 plant and animal species. This result is particularly striking because global warming has increased mean temperatures by less than 1 degree Celsius so far. These extinctions will almost certainly become much more widespread over time, because temperatures are predicted to increase by an additional 1 to 5 degrees in the next several decades. These local extinctions could also extend to species that humans depend on for food and resources.

The study also tested the frequency of local extinction across different regions, habitats, and groups of organisms. It found that local extinctions occurred in about half of the species surveyed across different habitats and taxonomic groups. However, the results showed that local extinctions varied by region and were almost twice as common among tropical species as among temperate species. This is important as the majority of plant and animal species live in the tropics. The results of this study contribute to our understanding of how plants and animals will respond to

global climate change and highlight the need to slow and prevent further warming.

Computers Can Take Social Media Data and Make Marketing Personas

Computers may be able to group consumers into marketing segments in real time just by observing how they respond to online videos and other social media data, according to a team of researchers.

In a study, computers used information from social media accounts to automatically build marketing personas, said James Jansen, professor of information sciences and technology, Penn State. Marketing research professionals typically create these personas to help editors and marketers better understand the behaviors of specific consumer groups, he added.

"A lot of times we have to use numbers in decision making, whether that's using numbers in understanding a market segment or an audience base or demographics, for instance," said Jansen. "But it's hard to make a decision looking at a bunch of complex numbers that most people don't understand. One way that has been proposed and implemented in a wide number of domains to understand consumers is through personas. Researchers take a bunch of market data and condense it into a fictitious person."

Marketers, who create personas manually with data from focus groups, ethnography methods and surveys, can then hold conversations and make decisions based on these personas.

"The problem with that, though, is that, in addition to being time consuming and expensive, they can rapidly become obsolete," said Jansen.

Computer-drawn personas, on the other hand, not only can be created in real time and at relatively low costs, but they can be updated quickly as economic conditions and demographics continue to change.

The researchers developed algorithms to analyse data, such as demographic information, topics of interest and customer interactions, from 188,000 subscribers of a news website. The data included the subscribers' YouTube profiles, which included demographic information such as gender, age and country location, and their interactions with videos on the site, such as the topics of videos watched by the users.

This site had posted approximately 2,807 videos to its YouTube channel that were viewed by 30 million users in 217 countries.

The algorithms then identified unique ways that groups of people were interacting with the information, in this case, news videos.

News site editors could use this information to better collect and target content to these audiences, said Jansen, who worked with Haewoon Kwak, research scientist and Jisun An, postdoctoral researcher, both of Qatar Computing Research Institute, Hamad Bin Khalifa University.

"Journalists want to have a better understanding of just who their actual users are," said Jansen. "They can use that information to reach readers with better titles, content and article framing."

While the researchers used news and information in this study, the technology could be applied to other types of consumer

transactions, according to the researchers, who presented their findings at the Second International Workshop on Online Social Networks Technologies held in Agadir, Morocco.

"The method is transferrable to other domains," said Jansen. "It could work at any consumer touchpoint — any place where we can see what the consumers are buying or what they are viewing before they buy and then tie it back to some demographics."

Jansen said the technology is also scalable and could use other types of social media to analyze consumer behavior and create marketing personas.

"We're now scaling this up to millions of users," he said. "And we could use other types of social media data, from Facebook or Twitter, for example."

Electron-photon Small-talk Could Have Big Impact on Quantum Computing

In a step that brings silicon-based quantum computers closer to reality, researchers at Princeton University have built a device in which a single electron can pass its quantum information to a particle of light. The particle of light, or photon, can then act as a messenger to carry the information to other electrons, creating connections that form the circuits of a quantum computer.

The research, published in the journal *Science* and conducted at Princeton and HRL Laboratories in Malibu, California, represents a more than five-year effort to build a robust capability for an electron to talk to a photon, said Jason Petta, a Princeton professor of physics.

"Just like in human interactions, to have good communication a number of things need to work out — it helps to speak the same language and so forth," Petta said. "We are able to bring the energy of the electronic state into resonance with the light particle, so that the two can talk to each other."

The discovery will help the researchers use light to link individual electrons, which act as the bits, or smallest units of data, in a quantum computer. Quantum computers are advanced devices that, when realised, will be able to perform advanced calculations using tiny particles such as electrons, which follow quantum rules rather than the physical laws of the everyday world.

Each bit in an everyday computer can have a value of a 0 or a 1. Quantum bits — known as qubits — can be in a state of 0, 1, or both a 0 and a 1 simultaneously. This superposition, as it is known, enables quantum computers to tackle complex questions that today's computers cannot solve.

Simple quantum computers have already been made using trapped ions and superconductors, but technical challenges have slowed the development of silicon-based quantum devices. Silicon is a highly attractive material because it is inexpensive and is already widely used in today's smartphones and computers.

The researchers trapped both an electron and a photon in the device, then adjusted the energy of the electron in such a way that the quantum information could transfer to the photon. This coupling enables the photon to carry the information from one qubit to another located up to a centimetre away.

Quantum information is extremely fragile — it can be lost entirely due to the slightest disturbance from the environment. Photons are more robust against disruption and can potentially carry quantum information not just from qubit to qubit in a quantum computer circuit but also between quantum chips via cables.

For these two very different types of particles to talk to each other, however, researchers had to build a device that provided the right environment. First, Peter Deelman at HRL Laboratories, a corporate research-and-development laboratory owned by the Boeing Company and General Motors, fabricated the semiconductor chip from layers of silicon and silicon-germanium. This structure trapped a single layer of electrons below the surface of the chip. Next, researchers at Princeton laid tiny wires, each just a fraction of the width of a human hair, across the top of the device. These nanometer-sized wires allowed the researchers to deliver voltages that created an energy landscape capable of trapping a single electron, confining it in a region of the silicon called a double quantum dot.

The researchers used those same wires to adjust the energy level of the trapped electron to match that of the photon, which is trapped in a superconducting cavity that is fabricated on top of the silicon wafer.

Prior to this discovery, semiconductor qubits could only be coupled to neighboring qubits. By using light to couple qubits, it may be feasible to pass information between qubits at opposite ends of a chip.

The electron's quantum information consists of nothing more than the location of the electron in one of two energy pockets in the double quantum dot. The electron can occupy one or the other pocket, or both simultaneously. By controlling the voltages applied to the device, the researchers can control which pocket the electron occupies.

"We now have the ability to actually transmit the quantum state to a photon confined in the cavity," said Xiao Mi, a graduate student in Princeton's Department of Physics and first author on the paper. "This has never been done before in a semiconductor device because the quantum state was lost before it could transfer its information."

The success of the device is due to a new circuit design that brings the wires closer to the qubit and reduces interference from other sources of electromagnetic radiation. To reduce this noise, the researchers put in filters that remove extraneous signals from the wires that lead to the device. The metal wires also shield the qubit. As a result, the qubits are 100 to 1000 times less noisy than the ones used in previous experiments.

Eventually the researchers plan to extend the device to work with an intrinsic property of the electron known as its spin. "In the long run we want systems where spin and charge are coupled together to make a spin qubit that can be electrically controlled," Petta said. "We've shown we can coherently couple an electron to light, and that is an important step toward coupling spin to light."

Mathematical Algorithms Calculate Social Behaviour

For a long time, mathematical modelling of social systems and dynamics was considered in the realm of science fiction. But predicting,

and at once influencing human behaviour is well on its way to becoming reality. Scientists at the Technical University of Munich (TUM) are currently developing the appropriate tools. This will allow them to simulate and improve security at major events or increase the efficiency of evacuation measures.

There is a long history of research aimed at predicting the behaviour of groups and influencing them. But, it seems practically impossible to precisely predict the behaviour of individuals, not least because of the myriad interactions between the physical, emotional, cognitive and social domains.

But things look quite different when considering people in traffic, in social networks and at major events in which they do not appear as individuals, but rather as part of a crowd. "People in masses behave akin to particles in a fluid or gas," explains Professor Massimo Fornasier, chair of the Department of Applied Numerical Analysis at TU Munich.

Analogy to Physics

In physics, it is not necessary to know the properties of every individual particle to calculate with a high probability the direction of flow of a large number of gas molecules. It is enough to understand their mean motion properties.

"We can take the same approach when looking at flows of human masses, animal swarms or interacting robots: Analogous to the force of attraction between molecules in a gas, we can describe generalised behavioural patterns as resulting from interacting social forces between individual agents and represent them in mathematical equations," says Fornasier, describing his approach.

Calculating Collective Behavioural Patterns

Professor Fornasier and his team have recently proven mathematical statements that demonstrate how surprisingly easy it is to automatically generate precise models for specific, relatively simple group interactions based on observed dynamics data.

Using computer simulations, the mathematicians can describe potential collective behavioural patterns of a large number of individuals who mutually influence each other in a given situation. "In the next step we can then also make predictions about future behaviour," says Fornasier. "And once we can calculate the behaviour of a group of interacting agents in advance, we are only one small step away from controlling them."

Informed Agents Follow the "Herd Instinct"

In an experiment conducted in May 2015 in collaboration with Consiglio Nazionale delle Ricerche (CNR) and the University of Rome 'La Sapienza' in Italy, Fornasier and his team demonstrated that the process is in fact amenable to influencing group behaviour.

To this end, the researchers assigned two groups of 40 students each the task of finding a specific location in a building. The scientists planted two incognito informed agents into one of the groups. By merely moving very determinedly in a predefined direction, the agents were able to steer the group toward the target spot.

This experiment demonstrates that taking control of self-organising systems, which also include groups of individuals, is possible with surprisingly little effort. The mathematicians

also confirmed that the results apply equally well to very large groups. "In fact, two to three agents per 100 individuals are sufficient," says Massimo Fornasier.

Herding Dog Strategy for Opinion Forming

The fact that his mathematical models are formulated in an entirely abstract environment makes them easily adaptable to a wide variety of situations. This facilitates finding efficient solutions for steering large masses of people through buildings in a stress-free manner or evacuating people in emergency situations.

"But we can also apply our results to other interesting domains in society, like the behaviour of investors in financial markets," says Fornasier. There, precisely coordinated activities by big investors can result in sizable market movements.

Opinion forming in groups also builds on the interactions of people. In their models, the mathematicians demonstrated that it is most effective to concentrate on the most radical defenders of a given opinion. If you manage to convince them, the rest of the group will follow.

"There is also a good model for this in nature," according to Fornasier. "To drive a herd of sheep in a desired direction, a good herding dog will always concentrate on the animal that is the farthest removed from the group. They achieve their goal by reining in the most stubborn animal."

Limits of Prediction

"For all the conceivably good application scenarios there remains, of course, the question of abuse," says Professor Fornasier. "The good news in this context is that we have also proven that behaviour is not so easy to predict or control for all kinds of dynamics and situations."

"An important prerequisite for predictability and controllability is that the myriad possible interactions between the agents in a large group can be reduced to a small number of effective ones," says Massimo Fornasier. "Forecasts function well in groups that show generalised patterns of behaviour."

However, with competing interactions, when the energy of individual agents is too large an equilibrium and, thus, concerted movement of the group of agents can no longer be imposed using simple, sporadic interventions.

"An extensive forecast of events like that accomplished by the mathematician Hari Seldon in Isaac Asimov's Foundation series or the all-encompassing control exercised in Aldous Huxley's 'Brave New World' will remain science fiction," says Professor Fornasier.

Mimicking Biological Movements with Soft Robots

Designing a soft robot to move organically — to bend like a finger or twist like a wrist — has always been a process of trial and error. Now, researchers from the Harvard John A. Paulson School of Engineering and Applied Sciences and the Wyss Institute for Biologically Inspired Engineering have developed a method to automatically design soft actuators based on the desired movement.

The research is published in *The Proceedings of the National Academy of Sciences.*

"Rather than designing these actuators empirically, we wanted a tool where you could plug in a motion and it would tell you how to design the actuator to achieve that motion," said Katia Bertoldi, the John L. Loeb Associate Professor of the Natural Sciences and coauthor of the paper.

Designing a soft robot that can bend like a finger or knee may seem simple but the motion is actually incredibly complex.

"The design is so complicated because one actuator type is not enough to produce complex motions," said Fionnuala Connolly, a graduate student at SEAS and first author of the paper. "You need a sequence of actuator segments, each performing a different motion and you want to actuate them using a single input."

The method developed by the team uses mathematical modeling of fluid-powered, fiber-reinforced actuators to optimise the design of an actuator to perform a certain motion. The team used this model to design a soft robot that bends like an index finger and twists like a thumb when powered by a single pressure source.

"This research streamlines the process of designing soft robots that can perform complex movements," said Conor Walsh, the John L. Loeb Associate Professor of Engineering and Applied Sciences, Core Faculty Member at the Wyss Institute for Biologically Inspired Engineering and coauthor of the paper. "It can be used to design a robot arm that moves along a certain path or a wearable robot that assists with motion of a limb."

The new methodology will be included in the Soft Robotic Toolkit, an online, open-source resource developed at SEAS to assist researchers, educators and budding innovators to design, fabricate, model, characterise and control their own soft robots.

Mind-controlled Toys: The Next Generation of Christmas Presents?

The next generation of toys could be controlled by the power of the mind, thanks to research by the University of Warwick.

Led by Professor Christopher James, Director of Warwick Engineering in Biomedicine at the School of Engineering, technology has been developed which allows electronic devices to be activated using electrical impulses from brain waves, by connecting our thoughts to computerised systems.

Some of the most popular toys on children's lists to Santa — such as remote-controlled cars and helicopters, toy robots and Scalextric racing sets — could all be controlled via a headset, using 'the power of thought'.

This could be based on levels of concentration — thinking of your favourite colour or stroking your dog, for example.

Instead of a hand-held controller, a headset is used to create a brain-computer interface — a communication link between the human brain and the computerised device. Sensors in the headset measure the electrical impulses from brain at various different frequencies — each frequency can be somewhat controlled, under special circumstances. This activity is then processed by a computer, amplified and fed into the electrical circuit of the electronic toy.

Professor James comments on the future potenti al for this technology: "Whilst brain-

computer interfaces already exist — there are already a few gaming headsets on the market — their functionality has been quite limited. New research is making the headsets now read cleaner and stronger signals than ever before — this means stronger links to the toy, game or action thus making it a very immersive experience.

"The exciting bit is what comes next — how long before we start unlocking the front door or answering the phone through brain-computer interfaces?"

New Classes of Electron Orbits Discovered

Phenomena like solar flares and auroras are consequences of magnetic reconnection in the near-earth space. These "magnetic reconnection" events are akin to magnetic explosions that accelerate particles as they rapidly change the topology of the magnetic field lines. Researchers in Japan have used a new Particle-In-Cell (PIC) simulator to understand how magnetic reconnection works for the tenuous plasma surrounding our earth and have identified new classes of electron orbits that help scientists understand the characteristics of the fast jets of electrons that stream from the reconnection region. The researchers explain their results this week in *Physics of Plasmas*, from AIP Publishing.

The ionized gas in space, called 'plasma,' is so tenuous that the charged particles (ions and electrons) rarely collide with each other, but move in very complex ways due to the electric and magnetic fields. This process is highly nonlinear because as the electrons move, they carry the electric current which in turn changes the electromagnetic field. The self-consistent nonlinear motion of the particles and of the electromagnetic field is a complex system that is hard to predict.

"We investigate basic mechanisms of magnetic reconnection in tenuous space plasma, by using a computer simulation that allows us to solve both the electromagnetic fields and the motions of virtual plasma particles," said Seiji Zenitani, a scientist at the National Astronomical Observatory of Japan. Although PIC simulations are widely used and can solve the motion of virtual particles, often all the particle trajectories are not checked. The reason is two-fold: on the one hand, because PIC simulation generates very large data sets; on the other, because until now, scientists had thought that all the basic orbits were already discovered in the 1980s. By comprehensively scanning the simulation data, the research team was careful not to overlook anything.

While this approach is straightforward for a small collection of particles, as a result of an extensive survey of PIC simulation with nearly two billion particles, researchers were able to identify several new classes of electron orbits.

"We were surprised to find 'noncrossing electron orbits' that do not cross the midplane, a finding contrary to conventional belief that all the particles cross the midplane (z=0) during magnetic reconnection," Zenitani said. So, while it is a standard strategy to track electron trajectories from the midplane, by definition, this does not work for the noncrossing electrons. Analysis suggests that the noncrossing electrons are the majority, at least in the number density. The particle orbits are fundamental elements for the kinetic physics of magnetic reconnection

which could lead to the revision of theoretical models.

"In addition, NASA's Magnetospheric Multiscale (MMS) mission observes the electron properties in and around near-earth reconnection sites now," Zenitani said. "Our results provide hints that will help to better interpret MMS data."

New Evidence Shows How Bacterium in Undercooked Chicken Causes Guillain-Barre Syndrome

A Michigan State University research team is the first to show how a common bacterium found in improperly cooked chicken causes Guillain-Barre Syndrome, or GBS.

The federally funded research, now published in the *Journal of Autoimmunity,* not only demonstrates how this food-borne bacterium, known as Campylobacter jejuni, triggers GBS, but offers new information for a cure.

If chicken isn't cooked to the proper minimum internal temperature, bacteria can still exist.

"What our work has told us is that it takes a certain genetic makeup combined with a certain Campylobacter strain to cause this disease," said Linda Mansfield, lead author and MSU College of Veterinary Medicine professor. "The concerning thing is that many of these strains are resistant to antibiotics and our work shows that treatment with some antibiotics could actually make the disease worse."

GBS is the world's leading cause of acute neuromuscular paralysis in humans and despite much speculation, the exact mechanisms of how this autoimmune disease develops have been widely unknown.

"We have successfully produced three preclinical models of GBS that represent two different forms of the syndrome seen in humans," Mansfield said. "Our models now provide a unique opportunity to understand how your personal genetic type may make you more susceptible to certain forms of GBS."

Another area of concern more recently among scientists is related to an increase of the disease due to the Zika virus. Mansfield said there are many other bacteria and viruses associated with GBS and her models and data could be useful in studying these suspected causes, as well as finding better treatment and prevention options.

Despite the severity of GBS, treatments have been very limited and fail in many cases. In fact, the use of certain antibiotics in Mansfield's study aggravated neurological signs, lesions and the number of immune antibodies that can mistakenly attack a patient's own organs and tissues.

"These models hold great potential for discovery of new treatments for this paralysis," Mansfield said. "Many patients with GBS are critically ill and they can't participate in clinical trials. The models we identified can help solve this."

Those suffering from GBS can initially experience vomiting and diarrhea, but can often write the symptoms off as eating bad food. One to three weeks later, they can begin to develop weakness and tingling in the feet and legs. Gradually, paralysis can spread to the upper body and arms, and even a respirator may be needed for breathing.

Mansfield now wants to move forward quickly to test drugs against GBS in her models.

"Of course new treatments would be wonderful," she said, "but therapeutics to prevent GBS from developing in the first place would be the best strategy so that people don't have to suffer with paralysis."

Campylobacter jejuni infects more than a million people yearly in the United States and is also known to trigger other autoimmune disorders such as Inflammatory Bowel Disease and Reiter's arthritis.

New Way to Trap Dangerous Gases

A team of researchers at the University of Texas at Dallas has developed a novel method for trapping potentially harmful gases within microscopic organo-metallic structures.

These metal organic frameworks, or MOFs, are made of different building blocks composed of metal ion centers and organic linker molecules. Together they form a honeycomb-like structure that can trap gases within each comb, or pore.

The tiny nano-scale structures also have the potential to trap various emissions from things as immense as coal factories and as small as cars and trucks. However, there are some molecules that are simply too weakly adsorbed to remain contained within the MOF scaffolding. Adsorption describes how an extremely thin layer of molecules (as of gases, solutes or liquids) can cling to the surfaces of solid bodies or liquids.

"These structures have the ability to store gases, but some gases are too weakly bound and cannot be trapped for any substantial length of time," said Dr. Kui Tan, a research scientist in the Department of Materials Science and Engineering at UT Dallas and lead author of the study published online in *Nature Communications*.

After studying this problem, Tan decided to try to introduce a molecule that can cap the outer surface of each MOF crystal in the same way bees seal their honeycombs with wax to keep the honey from spilling out.

In this case, Tan introduced vapors of a molecule called ethylenediamine, or EDA, that created a monolayer, effectively sealing the MOF "honeycomb" and trapping gases such as carbon dioxide, sulfur dioxide and nitric oxide within.

This monolayer is less than 1 nanometer in thickness, or less than half the size of a single strand of DNA.

To quantify how much gas was trapped and remained in the EDA-capped MOF structures, Tan and his team used time-resolved, in-situ infrared spectroscopy, testing the efficiency of this molecular "cork" to trap weakly adsorbed gases.

The presence of the gas molecules adsorbed in the MOF was displayed on a nearby computer screen as inverted peaks, which revealed that EDA vapor was able to effectively retain the greenhouse gas carbon dioxide for up to a day.

"Potential applications of this finding could include storage and release of hydrogen or natural gas to run your car, or in industrial uses where the frameworks could trap and separate dangerous gases to keep them from entering the atmosphere," Tan said.

As an added discovery, Tan found that a mild exposure to water vapor would disrupt the monolayer, penetrate the framework and fully release the entrapped vapors at

room temperature. Such selectivity of the EDA membrane opens up new options for managing gas emissions, he said.

"The idea of using EDA as a cap came from Kui who proceeded to do an enormous amount of work to demonstrate this new concept, with critical theoretical input from our collaborators at Wake Forest University," said Dr. Yves Chabal, head of the materials science and engineering department in the Erik Jonsson School of Engineering and Computer Science and senior author of the paper.

Predicting Extinction, with the Help of a Yule Tree

At this time of year, the words "Yule tree" may conjure images of brightly decorated balsam firs. But for Lea Popovic, an Associate Professor of Mathematics and Statistics in the Faculty of Arts and Science, a Yule tree is actually an advanced way to describe evolution.

In a new study published in *Mathematical Biology,* Popovic and recent Concordia graduate Mariolys Rivas (PhD 14) show how the present-day distribution of physical traits across species can help explain how the evolutionary process unfolded over time.

They used a tree-shaped graph called the Yule tree, first developed in 1924 by G. U. Yule to map genealogical history.

Visualising How Species Change

"The full history of the evolutionary process of a given species can be neatly described by a Yule tree," says Popovic.

"We extended Yule's model so that we would be able to track evolutionary processes that are dependent on specific phenotypes."

Reconstructing the evolutionary process has been a major challenge to scientists for decades because so much is unknown. And with increased planetary changes resulting in growing numbers of extinctions, these questions are even more pressing.

"The evolution of the visible traits of species — their phenotypes — is responsible for the diversity of all living organisms and for their ability to adapt to new environments," says Popovic.

"Recent research has shown how differences in phenotypes can affect how quickly species evolve or become extinct. Mathematical models can go a long way in helping us determine various elements of this process. But the possibility that diversification may be trait dependent implies that standard methods are not adequate for measuring the rates of evolution."

To address these concerns, Popovic and Rivas used math to map the rate at which new species are created or become extinct. They developed a new mathematical model that describes evolution as a process in which the length of time that species live until they go extinct — or give rise to other species — depends on their phenotype. Their model includes the possibility for the phenotype of the new species to change.

The Yule Tree Graph

The Yule tree is a graph with one edge coming in and two edges coming out of each branch-point. The branches represent the time periods between the evolution of new species. If the branch leads to a branch-point, it means a new species evolved. If the branch leads to a leaf, it marks an extinction. The leaves represent the species present today.

The graph also features "cherries," which represent two present species that are the closest to each other in evolutionary terms, and "pendants," which represent the evolutionary connection to another species that is slightly further from them in evolutionary terms.

Counting the number of different types of cherries and pendants helps determine the particular dependence on the phenotype of new species being created or going extinct.

Researchers Watch Biomolecules at Work

Scientists at the University of Bonn have succeeded in observing an important cell protein at work. To do this, they used a method that allows to measure structural changes within complex molecules. The further developed procedure makes it possible to elucidate such processes in the cell, i.e., in the natural environment. The researchers are also providing a tool kit, which allows a wide range of molecules to be measured. Their study has now been published in the journal *Angewandte Chemie International Edition*.

If we want to open a Christmas season walnut, we usually use a nutcracker. In the simplest case, this consists of two arms, which move against each other around a joint and can thus exert pressure on the shell. Very simple, actually — to understand how this kind of nutcracker works, it is sufficient for us to see it in action just once.

However, it is much more difficult to understand how cellular molecules work. They also alter their spatial structure as they work — similar to the nutcracker, where the arms open or close. These conformational changes tell experts a great deal about the way in which the molecule fulfills its job. Unfortunately, it is very difficult to measure these kind of movements because they occur on a very small length scale. This applies even more so if one wants to investigate the structural changes in the natural cellular environment, where countless simultaneous processes make it very hard to isolate any specific information from the general noise.

The working group from the Institute for Physical and Theoretical Chemistry at the University of Bonn has now succeeded in doing this. To this end, the scientists further developed a method that has been used for many years to measure distances within large molecules. "However, this normally only works in a test tube," explains the head of the study, Professor Olav Schiemann. "In contrast, our technique can also be used in cells."

The researchers used what is known as electron paramagnetic resonance spectroscopy (EPR) for their measurements. The molecule to be measured is usually given a magnetic marker at two different sites. Through radiation with microwaves, the polarity of one of these mini magnets is reversed. The magnetic field emitted by it is thus changed, which in turn influences the second mini magnet. This influence is greater the closer both markers are to each other.

"We now measure how strongly the second magnet reacts to the reverse polarity of the first," explains Schiemann. "From this, we can ascertain the distance between both markers." If — metaphorically speaking — both arms of the nutcracker are marked in this way, their movement against each other can be understood.

Magnetic Ruler Measurements

In principle, the technique is not new. "However, we have succeeded in producing a new kind of label with which we can mark a wide range of biomolecules in a site-specific way," explains Schiemann's staff member Jean Jacques Jassoy. Usually, these labels consist of radicals — which are chemical compounds that carry a single free electron. The electron acts as a magnet during the measurement. The problem here: single electrons are highly reactive — they try to form pairs of electrons as quickly as possible. The chemists at the University of Bonn thus used a very stable radical in their work — a so called trityl group. They created various derivatives of this trityl radical. Each of these magnetic markers is designed to target specific sites within biomolecules and thus enables several approaches for the structural analysis of different biomolecules.

In their study, the researchers used this methodological advance to investigate a protein from the cytochrome P450 group. These proteins occur in almost all living beings and fulfill important tasks, for instance during oxidation processes in the cell. "With our method, we were able to precisely measure the distance between two areas of the cytochrome to a fraction of a millionth of a millimeter," emphasises Schiemann's staff member Andreas Berndhäuser.

The procedure is suitable for making biomolecule conformational changes visible in the cell. At the same time, it also generally facilitates the clarification of molecular structures. Schiemann: "We are thus providing researchers with a new tool kit that could help answer many biochemical questions."

Smallest Transistor Ever

A research team led by faculty scientist Ali Javey at the Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) has done just that by creating a transistor with a working 1-nanometer gate. For comparison, a strand of human hair is about 50,000 nanometers thick

"We made the smallest transistor reported to date," said Javey, lead principal Investigator of the Electronic Materials program in Berkeley Lab's Materials Science Division. "The gate length is considered a defining dimension of the transistor. We demonstrated a 1-nanometer-gate transistor, showing that with the choice of proper materials, there is a lot more room to shrink our electronics."

The key was to use carbon nanotubes and molybdenum disulfide (M_0S_2), an engine lubricant commonly sold in auto parts shops. MoS, is part of a family of materials with immense potential for applications in LEDs, lasers, nanoscale transistors, solar cells, and more.

The findings were published today in the journal *Science*. Other investigators on this paper include Jeff Bokor, a faculty senior scientist at Berkeley Lab and a Professor at UC Berkeley: Chenming Hu, a Professor at UC Berkeley: Moon Kim, a Professor at the University of Texas at Dallas; and H.S. Philip Wong, a Professor at Stanford University.

The development could be key to keeping alive Intel co-founder Gordon Moore's prediction that the density of transistors on integrated circuits would double every two years, enabling the increased performance of our laptops, mobile phones, televisions, and other electronics.

"The semiconductor industry has long assumed that any gate below 5-nanometers wouldn't work, so anything below that was not even considered," said study lead author Sujay Desai, a graduate student in Javey's lab. "This research shows that sub-5-nanometer gates should not be discounted. Industry has been squeesing every last bit of capability out of silicon. By changing the material from silicon to M_0S_2,, we can make a transistor with a gate that is just 1 nanometer in length, and operate it like a switch"

When 'electrons are out of control'

Transistors consist of three terminals: a source, a drain, and a gate. Current flows from the source to the drain, and that flow is controlled by the gate, which switches on and off in response to the voltage applied.

Both silicon and M_0S_2, have a crystalline lattice structure, but electrons flowing through silicon are lighter and encounter less resistance compared with M_0S_2,. That is a boon when the gate is 5-nanometers or longer. But below that length, a quantum mechanical phenomenon called tunneling kicks in, and the gate barrier is no longer able to keep the electrons from barging through from the source to the drain terminals.

"This means we can't turn off the transistors," said Desai. "The electrons are out of control."

Because electrons flowing through M_0S_2 are heavier, their flow can be controlled with smaller gate lengths. M_0S_2can also be scaled down to atomically thin sheets, about 0.65 nanometers thick, with a lower dielectric constant, a measure reflecting the ability of a material to store energy in an electric field. Both of these properties, in addition to the mass of the electron, help improve the control of the flow of current inside the transistor when the gate length is reduced to 1 nanometer.

Once they settled on M_0S_2 as the semiconductor material, it was time to construct the gate. Making a 1-nanometer structure, it turns out, is no small feat. Conventional lithography techniques don't work well at that scale, so the researchers turned to carbon nanotubes, hollow cylindrical tubes with diameters as small as 1 nanometer.

They then measured the electrical properties of the devices to show that the M_0S_2 transistor with the carbon-nanotube gate effectively controlled the flow of electrons.

"This work demonstrated the shortest transistor ever," said Javey, who is also a UC Berkeley Professor of electrical engineering and computer sciences. "However, it's a proof of concept. We have not yet packed these transistors onto a chip, and we haven't done this billions of times over. We also have not developed self-aligned fabrication schemes for reducing parasitic resistances in the device. But this work is important to show that we are no longer limited to a 5-nanometer gate for our transistors. Moore's Law can continue a while longer by proper engineering of the semiconductor material and device architecture."

The work at Berkeley Lab was primarily funded by the Department of Energy's Basic Energy Sciences program.

The Incredible Shrinking Particle Accelerator

Long valued for their role in scientific discovery and in medical and industrial

applications such as cancer treatment, food sterilisation and drug development, particle accelerators, unfortunately, occupy a lot of space and carry hefty price tags. The Large Hadron Collider at CERN in France and Switzerland, for example — the world's largest and most powerful particle accelerator — has a circumference of 17 miles and cost $10 billion to build. Even smaller accelerators, such as those used in medical centers for proton therapy, need large spaces to accommodate the hardware, power supplies and radiation shielding. Such treatment facilities typically fill a city block and cost hundreds of millions of dollars to build.

But efforts are under way to make this technology more affordable and accessible by shrinking both the size and the cost without losing the capability. One of the most exciting developments is the plasma accelerator, which uses lasers or particle beams rather than radio-frequency waves to generate the accelerating field. Researchers have already shown the potential for laser plasma acceleration to yield significantly more-compact accelerators. But further development is needed before these devices — envisioned as almost literally "tabletop" in many applications — make their way into everyday use.

This is where advanced visualisation tools and supercomputers such as the Edison and Cori supercomputers at Lawrence Berkeley National Laboratory's National Energy Research Scientific Computing Center (NERSC) come in.

"To take full advantage of the societal benefits of particle accelerators, game-changing improvements are needed in the size and cost of accelerators, and plasma-based particle accelerators stand apart in their potential for these improvements," said Jean-Luc Vay, a senior physicist in Berkeley Lab's Accelerator Technology and Applied Physics Division (ATAP).

Vay is leading a particle accelerator modeling project as part of the NESAP program at NERSC and is the principal investigator on one of the new exascale computing projects sponsored by the U.S. Department of Energy (DOE). "Turning this from a promising technology into a mainstream scientific tool depends critically on large-scale, high-performance, high-fidelity modeling of complex processes that develop over a wide range of space and time scales," he said.

Vay and a team of mathematicians, computer scientists and physicists are working to do just that by developing software tools that can facilitate simulating, analyzing and visualising the increasingly large datasets produced during particle accelerator studies.

Accelerator modeling is an opportunity to help lead the way to exascale applications, noted ATAP Division Director Wim Leemans. "We've spent years preparing for this opportunity," he said, pointing to the already widespread use of modeling in accelerator design and the tradition of collaboration between physics and computing experts that has been a hallmark of ATAP's modeling work.

"One of the driving factors in our research is the transition to exascale and how data visualisation is changing," explained Burlen Loring, a computer systems engineer who is part of the collaboration, along with Oliver Rübel, David Grote, Remi Lehe, Stepan Bulanov and Wes Bethel, all of Berkeley Lab, and Henri Vincenti, a Berkeley Lab postdoctoral researcher from CEA in

France. "With exascale systems, traditional visualisation becomes prohibitive as the simulation get larger and the machines get larger — storing all the data doesn't work and the file systems and data bandwidth rates aren't keeping up with the compute capacity."

In-Situ to the Rescue

Now, in a paper published in *IEEE Computer Graphics and Applications* (IEEE CG&A), the team describes a new approach to this challenge: WarpIV. WarpIV is a plasma and accelerator simulation, data visualisation and analysis toolkit that marries two software tools already widely used in high energy physics: Warp, an advanced particle-in-cell simulation framework, and VisIt, a 3D scientific visualisation application that supports most common visualisation techniques. Together, they give users the ability to perform *in-situ* visualisation and analysis of their particle accelerator simulations at scale — that is, while the simulations are still running and using the same high performance computing resources — thus reducing memory usage and saving computer time.

"We have this push to transition a significant portion of our visualisation work over to the in situ domain," Loring said. "This work is a step in that direction. It is our first take on in situ for laser plasma accelerators and our first chance to use it on a real science problem."

A primary function of WarpIV is to manage and control the end-to-end, integrated simulation and in situ visualisation and analysis workflow. To achieve this, WarpIV supports four main modes of operation — batch, monitoring, interactive and prompt — each of which in turn supports a different approach to in situ scientific discovery. WarpIV also uses a factory pattern design to define simulation models, which allows users to create new simulation and in situ analysis models in a self-contained fashion; and Python-based visualisation and analysis scripts.

"One of the design factors that will make it easy for scientists to use WarpIV is the ability to use Python scripts that are autogenerated in VisIt," Loring explained. "The scientist takes a representative dataset before they make their runs and comes up with visualisation scripts. Then they open the representative dataset in VisIt and use the recording feature to automatically record their actions into a Python script. Then WarpIV takes these scripts and runs them in the in situ environment."

Another key feature of WarpIV is its integrated analytics — notably, filtered particle species, which enable users to pick out particular features of interest from the hundreds of millions of particles required for accurate simulation.

"Very often when you do a visualisation, particularly in situ, you want to minimize how much time you spend on it, and you can do this by focusing on particular features," Rübel explained. "In this case, for example, you need large numbers of particles to simulate the process, but the features you are interested in, such as the beam that is extracted from the background plasma, are going to be much smaller than that. So finding these features and doing the analysis while the simulation is running, this is what we call filtered species. It is a mechanism we developed not just to do plots, but to find what it is you want to plot."

Towards 3D Modeling

WarpIV, which Rübel initially prototyped in 2013, grew out of a collaboration between two

DOE SciDAC projects: SDAV (Scalable Data Management, Analysis and Visualisation) and COMPASS (Community Project for Accelerator Science and Simulation) programs. The work was also subsequently supported by DOE's CAMPA (Consortium for Advanced Modeling of Particle Accelerators) program.

The WarpIV toolkit, which continues to undergo development, was officially rolled out in June 2016 and is available via bitbucket. Initial testing has yielded positive results in terms of scalability, performance, usability and proven impact on science.

For example, in the research that resulted in the IEEE CG&A paper, the team ran a series of ion accelerator simulations in 2D and 3D to analyse WarpIV's performance and scalability. Comparison of these simulations revealed significant quantitative differences between the 2D and 3D models, highlighting the critical need for high-resolution 3D simulations in conjunction with advanced in situ visualisation and analysis to enable the accurate modeling and study of new breeds of particle accelerators.

In one 3D series, they tracked the run time for five categories of operations at 50-iteration simulation updates and found that, at each update, the visualisation, analysis and I/O operations consumed 11–15 per cent of the total time, while the rest was used by the simulation — a ratio the researchers consider "quite reasonable." They also found that the in situ approach reduced the I/O cost by a factor of more than 4000x.

There is great demand for 3D simulation codes that run in a reasonable time and perform accurate accelerator modeling with correct quantitative predictive power, Vay emphasised.

"We want to be able to conduct experiments on ion acceleration, so in this case it is very important to have a working simulation tool to predict and analyse all kinds of experiments and test theories," said Bulanov, a research scientist in the Berkeley Lab Laser Accelerator Center who works closely with Vay. "And if the simulations can't keep pace with the experiment, it would slow us down significantly."

Having in situ tools like WarpIV will be increasingly valuable as supercomputers transition to more complex manycore architectures, Vay added.

"WarpIV provides visualisation in 3D that we would not have been able to obtain easily using our previous visualisation tools, which were not scaling as well to many computational cores," he said.

World's Smallest Radio Receiver Has Building Blocks the Size of Two Atoms

Researchers from the Harvard John A. Paulson School of Engineering and Applied Sciences have made the world's smallest radio receiver — built out of an assembly of atomic-scale defects in pink diamonds.

This tiny radio — whose building blocks are the size of two atoms — can withstand extremely harsh environments and is biocompatible, meaning it could work anywhere from a probe on Venus to a pacemaker in a human heart.

The research was led by Marko Loncar, the Tiantsai Lin Professor of Electrical Engineering at SEAS, and his graduate

student Linbo Shao and published in *Physical Review Applied.*

The radio uses tiny imperfections in diamonds called nitrogen-vacancy (NV) centers. To make NV centers, researchers replace one carbon atom in a diamond crystal with a nitrogen atom and remove a neighboring atom — creating a system that is essentially a nitrogen atom with a hole next to it. NV centers can be used to emit single photons or detect very weak magnetic fields. They have photoluminescent properties, meaning they can convert information into light, making them powerful and promising systems for quantum computing, phontonics and sensing.

Radios have five basic components — a power source, a receiver, a transducer to convert the high-frequency electromagnetic signal in the air to a low-frequency current, speaker or headphones to convert the current to sound and a tuner.

In the Harvard device, electrons in diamond NV centers are powered, or pumped, by green light emitted from a laser. These electrons are sensitive to electromagnetic fields, including the waves used in FM radio, for example. When NV center receives radio waves it converts them and emits the audio signal as red light. A common photodiode converts that light into a current, which is then converted to sound through a simple speaker or headphone.

An electromagnet creates a strong magnetic field around the diamond, which can be used to change the radio station, tuning the receiving frequency of the NV centers.

Shao and Loncar used billions of NV centers in order to boost the signal, but the radio works with a single NV center, emitting one photon at a time, rather than a stream of light.

The radio is extremely resilient, thanks to the inherent strength of diamond. The team successfully played music at 350 degrees Celsius — about 660 Fahrenheit.

"Diamonds have these unique properties," said Loncar. "This radio would be able to operate in space, in harsh environments and even the human body, as diamonds are biocompatible."

This research was coauthored by Mian Zhang, Matthew Markham and Andrew M. Edmonds. It was supported in part by the STC Center for Integrated Quantum Materials.

WEB WATCH

In this Section, we present websites and a brief introduction about them. Inclusion of a site does not imply that *School Science* endorses the content of the site. Sites have been suggested on the basis of their possible utility to school systems.

- http://www.intelligencetest.com/iqtest/index.html

  This website involves several IQ tests, which are ideal for measuring differences in abilities for tasks that are analytical in nature, and that is why scores show significant correlations with academic achievement.

- https://www.braingle.com/

  Braingle is a place to solve puzzles, brush up on your trivia, play games and give your brain a workout. A large number of activities that include brain teasers, riddles, logic problems and mind puzzles are there in Braingle.

- https://www.funbrain.com

  Funbrain offers hundreds of games, books, comics, and videos that develop skills in math, reading, problem-solving and literacy. Educators and parents can trust this site to provide a fun and safe experience both at home and at school. Funbrain does not collect personally identifiable information from kids.

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To Our Contributors

School Science is a journal published quarterly by the National Council of Educational Research and Training, New Delhi. It aims at bringing within easy reach of teachers and students the recent developments in science and mathematics and their teaching, and serves as a useful forum for the exchange of readers' views and experiences in science and mathematics education and science projects.

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Published by the Head, Publication Division, National Council of Educational Research and Training, Sri Aurobindo Marg, New Delhi 110 016 and printed at Chaar Dishayen Printers (P.) Ltd., G-39-40, Sector-3, Noida- 201 301 (U.P.)

R.N. 7455/63

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भारतीय आधुनिक शिक्षा (त्रैमासिक) (Bhartiya Aadhunik Shiksha) A Quarterly Journal in Hindi	₹50.00	200.00
Primary Teacher A Quarterly Journal for Primary Teachers	₹65.00	260.00
प्राथमिक शिक्षक (त्रैमासिक) (Prathmik Shikshak) A Quarterly Journal in Hindi for Primary Teachers	₹65.00	260.00
फिरकी बच्चों की (अर्द्ध वार्षिक) (Firkee Bachchon Ki) Half-yearly	₹35.00	70.00

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