Chapter 23
Role of Open Educational Resources to Support School Science Education in India

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Abstract Although science teaching has witnessed a paradigm shift in recent years, a majority of schools in India continue teaching in traditional style with a sole aim of preparing students for examinations. With a view to change this scenario a project was undertaken to develop open educational resources for students, teachers and parents. Student's resources pertain to relevant games/puzzles, hands on activities, self-assessment tests and remedial/enrichment material. Teachers' resources provide guidelines to prepare teaching aids, achieve meaningful teacher–pupil interaction, manage classroom effectively and conduct action research. Resources for parents deal with everyday science, health/hygiene, out of school activities, identification/nurture of talent and parenthood in the 21st century. Sections on answers to children's questions, biographies of scientists, relevant articles on science education are common to all. These resources were developed in workshops involving practising teachers, science popularisers, social workers and parents. The units submitted by these authors in regional language were digitised and uploaded to the specifically designed website (www.mkcl.org/mahadnyan) that can be accessed free of cost. The field testing of these resources undertaken in about 200 schools catering to different sections of the society showed that they are quite effective in enhancing pupil-pupil, pupil–teacher and pupil–parent interactions.

23.1 Introduction

Since the latter part of the nineteenth century, our lives are influenced greatly by Information and Communication Technology (ICT). Developments in ICT have also influenced school education. E-learning as emphasised by Zemsky and Massey

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(2005) has a tremendous potential in the present situation. In many developed countries blackboards are replaced by 'Smart Boards' that facilitate effective teacher–pupil interaction. A computer and LCD projector are invariably made available in each classroom in these countries. Websites have become sources of information both for students and teachers. Realising the influence of ICT on school education National Aeronautics and Space Administration (NASA) has come out with an idea of Classroom of the Future (COTF). Established in different parts of the country COTF is trying to develop new methods of knowledge exploration using the available facility of ICT (www.cotf.edu). At the Open University in UK (UKOU), technology is being profusely used for teaching through distance mode. The Knowledge Media Institute (KMI) of the UKOU is working in the area of making use of ICT to improve teaching learning process in schools (www.kmi.open.ac.uk).

In the background of this international scenario one gets a dismal picture when one looks at the Indian education system. There is a large diversity in Indian education system. On one hand there are privately managed international schools that charge hefty tuition fees and provide good educational facilities. On the other hand, there are schools that lack even essential facilities. In the majority of these schools ICT has barely made its headway. India boasts to be providing IT experts to multinational companies. The software exports from India runs into billions of dollars. These developments in ICT have hardly benefited the school education in India. The situation in schools catering to students coming from socially disadvantaged communities is quite grave.

India, being a large country, is divided into different states formed on the basis of the language spoken by the people in the region. Following the policy of education through mother tongues, a large number of schools are operated both by the Government and private agencies to teach in regional languages. For example, Marathi is the language spoken by the people of the state of Maharashtra. Almost all the schools under the aegis of the local self-government, educational societies and tribal development departments of the government use Marathi as a medium of instruction. The teaching in these schools remains teacher-centred and textbook dominated. There is, therefore, a dire need to change this scenario. It is in this context an innovative project entitled "Open Educational Resources for Schools" (OER4S) has been launched by the Homi Bhabha Centre for Science Education (HBCSE) in collaboration with Maharashtra Knowledge Corporation Limited (MKCL) and Indian Consortium for Educational Transformation (ICONSENT) to improve the quality of education in Marathi medium schools of the state of Maharashtra. The project aimed at designing appropriate educational resources that can be used by school students, their teachers and parents. This chapter gives a comprehensive account of the project implemented in the state of Maharashtra in India for six academic years from 2007–2008 to 2012–2013.

23.2 Open Educational Resources

23.2.1 Meaning of OER

The phrase 'Open Educational Resources (OER)' was first coined in 2002 at UNESCO's Forum on the Impact of Open Course-ware for Higher Education in Developing Countries. OER are teaching, learning and research resources that reside in the public domain or have been released under an intellectual property licence that permits their free use or repurposing by others. These resources include full course, course materials, modules, textbooks, streaming videos, tests, software and any other tools, materials or techniques used to support access to knowledge (UNESCO 2002). The Organisation for Economic Co-operation and Development (OECD) defines OER as: "digitised materials offered freely and openly for educators, students, and self-learners to use and reuse for teaching, learning, and research. OER include learning content, software tools to develop, use, and distribute content, and implementation resources such as open licences" (OCED 2007). The Commonwealth of Learning has adopted the widest definition of Open Educational Resources (OER) as 'materials offered freely and openly to use and adapt for teaching, learning, development and research' (COL 2000). For public library of Science (PLoS) open includes free access, unrestricted distribution, authors retains right to attrition and papers are deposited in public online archive.

23.2.2 OER Movement

The OER movement gained momentum in the first decade of twenty-first century. OER foundation has been set up to facilitate free sharing of knowledge among the information seekers (www.oerfoundation.org). Internationally, there is a growing concern among higher education institutions to create Open Course-ware (OCW) contents and participate in the open education movement. Between 2002 and 2007, the Hewlett Foundation, invested a huge sum in its own OER initiative. UNESCO has created a Free and Open Source Software Portal and with the International Council in Distance Education (ICDE) it has set up a task force to develop an international approach to OER. The Teacher Education in Sub-Saharan Africa (TESSA) consortium created by, and working across, nine countries in Sub-Saharan Africa began supporting education in Africa. Open Learning Initiative (OLI) by Carnegie Mellon University, China Open Resources for Education (CORE), Open Learn Project of the UK Open University, Best First Year On Line Project of Canadian Virtual University and Athabasca University, The Open University of Israel's portal, the Multilingual Open Resources for Independent Learning (MORIL), Paris Tech OCW project of eleven member universities of France and Japanese OCW Alliance of ten participating universities in Japan are some of the prominent OER initiatives. Some more OER projects are emerging at

universities in Australia, Brazil, Hungary, Iran, Russia, Spain, Saudi Arabia and Korea (Daniel et al. 2006). There are many other institutions and business houses and even individuals, creating open course-ware content like Apple Learning Interchange (www.ali.aple.com), Connexions, EducaNext (www.educanext.org), Eduforge (www.eduforge.org), iBerry (www.iberry.com), Gateway to Educational Materials (GEM), OCW Finder, Wikiversity, World Lecture Project, Maricopa Learning Exchange. Among the more notable of the many other current OER projects are EduTools, GLOBE, the African Digital Library, the Knowledge Commons and the Open Content Alliance. There are a large number of Open Access (OA) journals worldwide and the number is continuously increasing. Freely accessible encyclopaedias like Wikipedia are growing in size and quality day by day.

23.2.3 OER in India

Efforts are being made in India to transform it into a knowledge society. Access, equity and quality are the main foci of new initiatives in school and higher education in India. Knowledge Commission (2007) set up by the Government of India has brought out these aspects very clearly. Nowadays, many institutes are taking initiatives specifically for creating open educational tools and resources that are directed towards basic sciences and engineering education. One significant undertaking in this area is the National Program on Technology Enhanced Learning. It is a joint venture by seven Indian Institutes of Technology (IITs) and the Indian Institute of Science (IISc) funded by the Indian Ministry of Human Resource Development (MHRD), to enhance the quality of engineering education in the country by developing curriculum-based video and web courses (http://nptel.iitm.ac.in). Another illustrative open education initiative is Eklavya, launched by Indian Institute of Technology, Bombay. In this project, content developed in various Indian languages is distributed over the Internet. The Eklavya project has developed an Open Source Educational Resources Animation Repository (OSCAR) that provides web-based interactive animations for teaching. OSCAR also provides a platform for student developers to create animations based on ideas and guidance from instructors. Funding for the Eklavya and OSCAR project comes mainly from private industries. A third prominent initiative, E-Grid, supported by the MHRD and the Indian Institute of Information Technology (IIIT), provides subject-specific portals that are developed and maintained by subject domain experts. Currently, this programme offers OER only for science and engineering. A Confederation of Indian Industry (CII) has developed a collaborative e-Learning system and portal under its initiative Shiksha India, which will help Indian students search for contents in difficult topics. The portal (www.eshikshaindia.in) can be accessed by anyone free of cost and will equip schools with e-Learning facilities help students understand difficult concepts better. The portal is basically designed for students aged between 12 and over. Similarly, Brihaspati (www.brihaspatisolution.co.in),

and Vimukti (www.vimukti.com), Sakshat (www.sakshat.ac.in), E-Gyankosh (www.egyankosh.ac.in), Vidyanidhi (www.vidyanidhi.org.in), etc., help Indian students in making their learning easier.

Despite the promising sets of projects mentioned above there has been no systematic national effort to develop a strategy for designing and delivering OER for disadvantaged groups of students (Sharma 2005). Such a strategy would need to address the development of OERs for a wider range of disciplines in regional languages, as well as to allow greater adoption among teachers and students. The need for OER is growing and likely to continue to do so as jobs, technology and knowledge change rapidly. Connectivity to the Internet is increasing in the country with great speed. Low-cost computers and enhanced mobile phones are being developed in the country. The time, thus, is ripe in India for developing and distributing OER that address local needs and requirements.

23.3 Identification of Resources

The task of identifying resources was undertaken through the meeting of experts, practising school teachers, science/maths popularisers, social workers and enthusiastic parents. Resources supporting school science from grades 1 to 10 were designed for all the three stakeholders of school education: students, teachers and parents. These terms are used here with wider connotations. All those who have willingness to learn irrespective of age or educational qualifications are called as 'students'. Similarly, teacher is a person concerned with school education directly or indirectly. Along the same lines, all those who wish to provide support to their wards in their educational endeavour are termed as 'parents'.

While preparing material for students the entire syllabus of school science prescribed by the Bureau of Text Book Production and Curriculum Research, Government of Maharashtra was analysed. Through this analysis, 36 main concepts in science were identified. Inputs are provided to the students for each of these concepts. They pertain to conceptual clarifications, interesting anecdotes, explanation of technical terms, tests for self-assessment, additional information, problem solving assignments, etc.

Needs and requirements of the practising science teachers were taken into account while preparing resources for them. The field work carried out by HBCSE in rural part of India brought out the fact that the practising teachers need inputs in three areas: Content, Pedagogy and Assessment (Kulkarni et al. 1994). Resources designed based on these experiences include Clarification of crucial concepts in school science, teaching aids/PowerPoints that can be used in the classroom proceedings, Activities that can be performed in the classroom, projects that can be given as an assignment to the students, pedagogic guidelines for effective classroom management, etc. Issues like research and innovation in science education and assessing students' learning with focus on Continuous Comprehensive Evaluation (CCE) are also discussed under OER for teachers.

Resources for parents were designed based on the felt needs of the society in twenty-first century. They pertained to science in everyday life, health including community health and hygienic practices, changes in parenthood (based on twenty-first century demands), out of school activities to support school science, identification and nurture of talent with emphasis on multiple intelligence, etc.

Apart from specific resources directed to fulfil the requirements of students, teachers and parents, additional resources were also designed that would prove useful to all stakeholders. Known as the common resources they include: (1) Life sketches of scientists, (2) Answers to Children's questions, (3) Articles on current trend in school education and (4) Information about events and awards.

23.4 Development of Resources

23.4.1 Resource Generation Workshops

The open educational resources were developed through specifically organised workshops at HBCSE and at other places in the state of Maharashtra. Experts from various fields concerned with school education were invited for the workshops. They were first acquainted with the concept of open learning. The importance of open source for self-learning was emphasised and model OER was made available for the perusal of the resource persons. It was noticed that the majority of resource persons had a tendency to write material in a dull and dry traditional textual style. It took a long time to convince them that units prepared in a nontraditional style would better appeal to the user. Some of the styles adopted were as follows.

23.4.1.1 Storytelling

There is a long tradition of storytelling within India. Stories from Panchatantra, which is an ancient Indian technique of moral stories using animate as well as inanimate objects around us, are told in informal settings in Indian homes. Since storytelling appeals to people of all ages, it was thought appropriate to use this style in writing and explain the concept through a relevant story.

23.4.1.2 Dialogue Mode

The traditional style of giving information about a concept does not lead to active participation of the learner. To achieve this end, it was suggested to prepare units in a dialogue mode. This dialogue could take any form: a discussion between a pupil and a teacher, conversation between two children, argument between a child and an adult.

23.4.1.3 Question–Answer Mode

Children are curious by nature. Teachers and parents also have many unanswered questions. It has been noticed that the question–answer sessions arranged in a school setting are appreciated both by teachers and students (Agarkar et al. 2002). Hence, question–answer mode in the development of OER was also adopted.

23.4.1.4 Success Stories

Practising teachers, parents and voluntary workers continuously innovate in communicating science content. Some of the innovations failed but many of them succeeded. These success stories, it has been noted, goes a long way in motivating others to follow the new style. The resource persons were, therefore, encouraged to put down their success stories for the benefit of all concerned with school education.

23.5 Processing of Resources

Through the workshops, HBCSE received units written in regional language Marathi. These units had to be processed before they could be published on the website. The work actually needed five steps: digitization, illustration, quality check, tagging and compilation. Each of these steps is described below.

23.5.1 Digitization

Devanagari is the script used for writing in Marathi. There are various softwares available in the market to digitize material written in Devanagari script. However, many of them have limitations as the user must also have the same software with him/her to read the content. In order to overcome this problem, it was decided to use Unicode font that has universal acceptance. Thus, the entire handwritten material was digitised using Unicode package available free of cost.

23.5.2 Illustration

This task was assigned to a well-trained artist. In rare cases, relevant figures were taken from available sources like websites and printed materials. Most of the time, the figures were drawn using computing facility. While drawing pictures, care was taken to ensure that they come as live entity. For that illustrator often resorted to cartoon drawing.

23.5.3 Quality Check

The units that were digitised and illustrated were then subjected to quality assurance. This task was entrusted to subject experts, method masters and social workers. Quality assurance methods were strictly applied on all the digitised units. Care was taken to ensure that the content is accurate and unambiguous; illustrations used are appropriate, activities suggested are relevant; sequencing of the points supports logical presentation; pictures, diagrams, sketches are used where necessary and contributes to better learning. Language also formed an important criterion in quality assurance. It was ensured that the language is simple and appropriate for the stage, technical terms used in the descriptions are explained, metaphors used are suitable and does not convey inaccurate or wrong message. Necessary changes were made in the units based on the inputs received through Quality Assurance Workshops.

23.5.4 Tagging and Compilation

Once the unit has been finalised it was tagged suitably to indicate the stakeholder (students, teacher or parent), level (primary, upper primary or secondary), topic and the subtopic where it should go. The finalised units were compiled using Content Development and Integration Tool (CDIT) made available by MKCL. This tool allowed the resources to be put together in specific boxes. Once adequate material was put together by HBCSE, the Web-master from MKCL published the material on the specially designed website.

23.6 The OER Website

23.6.1 Designing

The responsibility of designing and maintaining the website for the project was entrusted to the MKCL. It was named as mahadnyan, to indicate the initiative taken by Maharashtra in this crucial area (www.mkcl.org/mahadnyan).

23.6.2 The Home Page

The Home Page of the website has a welcome address written both in English and Marathi. On the left hand side it displays logos of all three participating institutions involved in the implementation of the project. The page also has windows that can give information about the project, nature of material prepared for students, teachers

and parents. One can also look at the details of the workshops held for the development of OER. An important aspect of the home page is the choice to log in as a student, a teacher or a parent. Before one logs in, there is a need to register first.

23.6.3 Accessing the Resources

To facilitate the access, the resources are divided into four categories: Resources for Students, Resources for teachers, Resources for Parents and Common resources. Common resources are made available for each of the stakeholders (students, teachers or parents). In order to access these resources, a person needs to log in into his/her account. When a child logs in as students, he/she would get access to resources for students as well as common resources. Nature and scope of these resources are discussed in the following sections.

23.7 Resources for Students

The resources for students are arranged concept-wise. For convenience, they are divided into three categories: primary, upper primary, and secondary (See Appendix). While developing these resources care is taken to ensure that technical terms used in the descriptions are explained with their etymologies. Ample examples from daily life are given to illustrate the point. Some simple activities are suggested to gain practical experience. In short, it can be said that these units are prepared in such a way that a typical child from a typical village will be able to read and understand without adult intervention.

Once the student clicks on the main concept, he/she can see the list of sub-concepts. He/she can then choose one of them depending on her/his requirement. Under each sub-concept, one finds resources in the form of articles, activities, skits, power points, etc. Student has a choice to click on one of them as per his/her liking. He/she can either save the page, send it to someone or print it for further use.

23.8 Resources for Teachers

If a person registers as a teacher, he/she would also get two options: Common resources and Open Educational Resources for teachers. If he/she clicks on the second option, resources relevant to teaching of school science would appear. For convenience they are grouped under six headings: (1) Conceptual Explanations, (2) Teaching Aids, (3) Experiment/Activity/Project, (4) Pedagogic Guidelines, (5) Research/Innovation and (6) Assessment of Students' Understanding. Teacher

has the freedom to choose the resources that he/she requires for immediate use. Nature of content under each heading is described below.

23.8.1 Conceptual Explanations

Primary and upper primary schools in India rarely appoint a specialised science teacher. The understanding of science among these teachers, with just high school education, is certainly inadequate. In contrast almost all the secondary schools would have appointed a specialised science teacher. But, they would have to teach all branches of science irrespective of their subject of specialisation at their graduation. Hence, many of them are unable to give justice to the subject that they have not studied at higher level. Taking these needs into account, a folder on Conceptual Explanations is included. Since it is almost impossible to explain all the concepts in school science, some major concepts, found difficult by teachers, are selected and explained through examples. Wherever required, a reference material for reading is suggested. Once a teacher clicks on the main folder entitled conceptual explanation he/she would get a list of subfolders: concept maps, lesson plan and explanatory notes.

23.8.1.1 Concept Maps

Concept map is an idea where relationships of the concept at hand with major as well as minor concepts are shown (Canas and Novak 2009). The practice of preparing a concept map has been used effectively in teaching different subjects both at school as well at college levels. A large number of such maps are prepared for important concepts in school science and are made available on the website. In addition suggestions to prepare similar maps are provided for the benefit of teachers.

23.8.1.2 Lesson Plan

The guidelines for preparing lesson plans are provided in teacher training colleges. Based on these guidelines practising teachers are expected to prepare their own plans and implement them in the classroom in dealing science concepts. However, the practice of preparing lesson plan is not followed regularly in all schools. Hence, this section attempts to help teachers for preparing lesson plans. Sample lesson plans encompassing the activities to be undertaken by the teacher, assignments to be given to the students and the method of evaluation to be followed at the end of the lesson are given as illustrative examples.

23.8.1.3 Explanatory Notes

Due to limitations on the number of pages, the concepts in science are treated very briefly in textbooks. Usually, additional explanations, illustrative examples and relevance of school content to daily life are brought out through the teachers' handbooks. However, the practice of using such handbooks hardly exists in Maharashtra. Hence, explanatory notes to clarify scientific concepts are provided in this section.

23.8.2 Teaching Aids

It is often advised that concepts in science should be taught using teaching aids. The picture in the classroom is, however, contrary to this expectation. Teaching aids are seldom used during day to day teaching. In order to help teachers using teaching aids they were made available on the website under two headings: (1) PowerPoints and (2) charts and models.

23.8.2.1 Power Points

With the advent of technology, the use of PowerPoints is becoming common in school education. However, one hardly witnesses the use of PowerPoints in Marathi medium schools. Difficulties encountered by teachers are twofold. First, teachers are not competent in preparing PowerPoints and second there are many packages used for typing Marathi that uses Devanagari script. In order to solve this problem it was decided to prepare power points and make them available so that teachers can use them directly in their classrooms. The material is processed using Unicode package. As a result, the material can be downloaded whenever they want without any difficulty.

23.8.2.2 Charts and Models

It is well known that charts and models play a key role in explaining science concepts. Once again, there is a problem of resource crunch as only a few charts and models are available in school laboratory. As a result, teachers cannot lay hands on many charts and models in their schools. Guidance is, therefore, offered to teachers on how to make charts and models using easily available material. At the same time inputs are given on how to use available charts and models effectively to clarify scientific concepts among students.

23.8.3 Experiment/Activity/Project

Role of experiments, activities and projects in the teaching of science is beyond doubt. This section attempts to give helping hand to the teachers in these areas. The resources in this category are divided into three parts: experiment, activity and projects.

23.8.3.1 Experiments

Most of the primary and upper primary schools do not have well equipped laboratories. Even in secondary schools laboratory space and resources are often inadequate. In such cases teachers have to resort to easily available material to perform experiments. In one of its field projects HBCSE had designed a kit of apparatus that can be used to perform all the experiments at primary and upper primary stages of education. Descriptions of this kit along with a sample of experiments that can be performed are given in this section. Care is taken to make sure that these activities are easy to perform and can foster interest among both teachers and the students. The value of each experiment in explaining concepts in school science is highlighted.

23.8.3.2 Activities

Teaching in Indian schools is mainly chalk and talk. Teacher goes on giving information and students, accepting passive role in the classroom, devote to simply listening to what has been said or told. There is hardly any opportunity for students to take an active role in classroom deliberations. In this context a variety of activities are suggested in this section where students can play an active role.

23.8.3.3 Projects

Although the project-based teaching is adopted in many developed countries, it is hardly practiced in Indian schools. The main reason is that teachers have no experience in teaching through projects. Moreover, they do not have access to relevant projects that can be used in the teaching of science. With a view to overcome these lacunae, a large number of projects are described in this section. In addition, first hand experiences of engaging students in educationally relevant projects are given. It is not necessary that projects be implemented in school itself. They can be given as home assignment where students work on the projects during their leisure time and come out with some good findings (Agarkar 1992).

23.8.4 Pedagogic Guidelines

Teachers teaching at primary levels usually possess the qualification of Higher Secondary School Certificate Examination (H. S. S. C.) and Diploma in Education (D. Ed.) while teachers teaching at upper primary and secondary classes have Bachelor's degree in Science (B. Sc.) and a Bachelor's degree in Education (B. Ed.). Thus, school teachers have some exposure to pedagogic techniques and principles of education. These inputs once received, however, are not adequate as they are of general nature. In actual practice, a teacher might be dealing with a special group of students like tribal children, students of factory workers or students whose parents are engaged in frontier research. The needs and requirements of these groups of teachers are different and they have to adjust with them. Second, the thinking of how children acquire knowledge has undergone drastic changes in the recent past. These changes demand serious thinking in the way classrooms are arranged, activities performed and assignments given. It is, therefore, necessary that practising teachers be given inputs in all the above matters. They are categorised as (1) Learning difficulties, (2) Teaching methods and (3) Classroom management. Resources have been prepared and made available under each of these three categories.

23.8.4.1 Learning Difficulties

The state of Maharashtra adopts a non-retention policy in primary classes. It means students are pushed to higher levels without ensuring mastery in learning. As a result, many students reached higher grade levels with poor initial knowledge. This situation often creates problems in discussing concepts in science that demands previous knowledge. In such cases, remedial inputs need to be given to the students. This section focuses on identifying learning difficulties and providing remedial inputs as understood in a project undertaken at HBCSE to teach science and mathematics to socially deprived students (Agarkar 2010).

23.8.4.2 Teaching Methods

Teaching method that a teacher follows in the classroom is based on a variety of things. First, it depends on the personality of the teacher. Second, it depends on the teacher's awareness of new developments in school education. Third, it depends on different models available to the teacher. This section, therefore, provides resources that discuss the changing scenario in educational psychology from behaviourism to constructivism. The impact of this change on science education is elaborated. An open ended approach of teaching is now advocated in school education all over the world. Ample examples on how it can be achieved in science classes are provided through these resources.

23.8.4.3 Classroom Management

It is now well accepted that a teacher has to be a good manager to achieve success in handling classroom effectively. Classroom management has received great importance in recent years in India as a large number of first generation learners have entered the school system (Kulkarni 1978). With the advent of technology and the spread of television all over the country the expectation of different sections of the society has also changed and the teacher has a big challenge in fulfilling these expectations. At the same time the teacher has a responsibility of developing citizens who can use their knowledge to deal with problems within a specific context. A variety of relevant resources in this regard are provided in this section.

23.8.5 Research and Innovation

Science education research as a discipline that received recognition towards the last half of the twentieth century (Fensham 2000). Many universities came forward to establish departments of science education. Faculties working in these departments came out with many innovative ideas for the teaching of science. A large number of science education projects were undertaken in different parts of the world. Information available in this context is huge. An attempt, however, was made to provide concise information of research activity in science education. Under this main theme, there are three sections: (1) Review of research (2) Recent trends in education and (3) Action research.

23.8.5.1 Review of Research

Serious research is being pursued in science education all over the world. Most of these research have been published in peer reviewed journals written in English or foreign languages like French, Japanese, Chinese, German, etc. Teachers working in the state of Maharashtra hardly have access to these journals. Even if they are made available many teachers do not have the competence to decode them and use for the benefit of their profession. Hence, an attempt was made to make available some research papers in a simplified manner in Marathi.

23.8.5.2 Recent Trend in Education

The National Curriculum Framework of 2005 brought out by the National Council of Educational Research and Training (NCERT), an apex body in education in India, focuses on constructivist approach of teaching. A lot of research works is being carried out based on this new thinking in education all over the world. In spite of

these developments, a large number of practising teachers are ignorant of this approach of teaching. This section attempts to acquaint the teaching community with recent trends in education with its impact on the teaching of science at school level.

23.8.5.3 Action Research

The term action research was coined first to deal with local problems urgently. Entering into education this term has gained a specific meaning as a piece of work undertaken by practising teachers while he/she is in action. As the term specifies, one need not follow a comprehensive design or involved serious research methodology. Nevertheless, teachers need to be familiar with the strategy of educational research and mathematical techniques used to deal with the data collected. This aspect is taken into consideration while writing resources under this section. Ample numbers of action research projects completed by practising science teachers are included in this section.

23.8.6 Assessing Students' Understanding

Assessment of students' understanding is an important task that teachers have to undertake in their profession. Assessment is done for different reasons. First, assessment is conducted to find out the difficult spots in the understanding of the concepts. Tests used for this purpose are commonly called 'Diagnostic Tests'. The success of any teaching is measured by administering achievement tests to find out how far students have acquired the knowledge imparted to them. Apart from imparting information in science, school education envisages behavioural as well as attitudinal changes among students. Tests need to be administered to see how far these objectives are achieved. Such a mode of testing is known as 'Outcome based Testing'. The section on evaluation attempts to provide tests of all three types.

23.8.6.1 Diagnostic Tests

Crucial concepts that are found difficult for a majority of students are identified and sub-concepts embedded within a major concept are found out. Questions are framed for each sub-concept and are put sequentially in the questionnaire. These questionnaires are then administered to the students. Analysis of response sheets enables to understand how well the student has captured the essence of the concept and what is causing hurdle in the understanding. In addition, diagnostic testing would also help to identify misconceptions if any possessed by students. Sample diagnostic tests for some important concepts in school science are given along with the guidelines of how to prepare such tests.

23.8.6.2 Achievement Tests

These types of tests are commonly used in school education. In twentieth century, essay type questions were asked more commonly in school examinations as this mode of assessment tests the writing skill of the child in addition to his/her understanding of the topic. There was a problem of subjectivity associated with this mode of evaluation. In order to avoid subjectivity and to bring in objectivity multiple choice tests were adopted. In this mode of testing, possible alternatives are provided below the question and the child is expected to choose the most appropriate one. Framing of Multiple Choice Questions (MCQ) is a skilful job as the alternatives given should be equivalent and should test conceptual understanding. Hence, the mechanism of creating MCQs along with the sample questions is included in this section.

23.8.6.3 Outcome-Based Tests

As Einstein has said "The real purpose of education is to teach how to think". It is important to see whether children have achieved this skill. At the same time science teaching envisages the development of rational thinking, experimental skills, an eye for detail, analysis and synthesis of data, etc. This section provides a variety of tests being created to assess the development of these skills.

23.9 Resources for Parents

Studies have shown that home environment plays a crucial role in the scholastic progress of a child. Hence, parents have been identified as important stakeholders in school education in designing Open Educational Resources. The resources for parents are divided into six categories: (1) Everyday Science, (2) Health and Hygiene, (3) Parenthood in twenty-first century, (4) Teaching-learning process, (5) Out of school activities to support school education and (6) Identification and nurture of talent. Nature and scope of resources prepared under each of the above categories are given below.

23.9.1 Everyday Science

This section is devoted to acquainting the parents with science that is used in everyday life. The focus is on bringing out scientific method of investigation and presenting the data in a quantitative manner. There is so much science included in everyday events. Take the food we eat as an example. Starting from food production, its preservation and processing there is science at every stage. Moreover, developments in science and technology have provided us a large number of

gadgets both at home and at schools. It is necessary that parents must be made conversant with the working of these gadgets. Only then they will be able to explain mechanism and provide guidance for trouble shooting to young children.

23.9.2 Health and Hygiene

When we think of health we usually limit to personal health. There is, however, a need for taking care of family as well as community health as we cannot live isolated from either. Resources under health and hygiene are, therefore, divided into three parts: personal health, family health and community health.

23.9.2.1 Personal Health

Human body is a complicated machine. It runs properly as long as there is a proper coordination among all parts of the body. Lack of coordination can create problems. At the same time an individual can suffer from a variety of illnesses. There are curative measures that an individual has to undergo in such cases. Before that, there are preventive measures that one can follow to avoid such diseases. These preventive measures are discussed. Medical science has witnessed unprecedented growth in the past few years. Doctors now prescribe so many tests to identify the exact cause of a disease. A common person is often ignorant of these tests. An attempt in this section is, therefore, made to explain the mechanism and meaning of various diagnostic tests that doctors usually prescribe.

23.9.2.2 Family Health

Family bonds in India are quite strong. One often finds three generations of people living together in a single house. There are certain advantages of having a large number of family members living together. However, illness can be a curse for such big families. Contagious diseases can quickly spread uncontrollably in such families. Hence, due care has to be taken to maintain family health all the time. Drinking water is an issue of critical importance in any family as it can spread many illnesses especially during rainy seasons. In such a situation, every family has to take care of making drinking water potable using some simple techniques. Issues related to family health are discussed in this section.

23.9.2.3 Community Health

From the time man learned to farm, villages emerged. Now one sees towns and cities with large numbers of people living together. Human beings have witnessed

epidemics like plague and cholera in the past. Although we have overcome some of these diseases, there are other problems creeping in. In such cases the health of the community is at stake. Hence, care has to be taken to ensure that community health is maintained well at all times. Defecation in open areas is a major problem in developing countries. A campaign is being launched in India to have toilets for every house. There is a need to create awareness among the masses. This is exactly the point that is made in the article prepared by a teacher working in rural area of the state of Maharashtra.

23.9.3 Parenthood in twenty-first Century

Parenthood has witnessed drastic changes in the past few decades. Mass media has entered each household and become an important aspect of day to day entertainment. Some control has to be brought in for the judicious use of these media. If used properly they can become a good resource of new knowledge. In addition, there are now a large number of resources through which students can get information. Parents have a responsibility to guide children to make proper use of the resources. The main purpose of the contents in this section is to prepare parents to provide balanced guidance to their children in the present world while taking into account the futuristic viewpoint.

23.9.4 Teaching Learning Process

A large number of researchers are trying to understand how learning takes place among school students. Based on this understanding many of them have come out with effective methods of teaching school science. Parents usually are ignorant of these developments and try to help students the way they were taught in their childhood. Such a help can sometime be counterproductive. An attempt is, therefore, made in this section to acquaint parents with research studies in science education and effective methods of teaching developed. It must be mentioned here that the task is quite difficult as technical work has to be described in laymen's language.

23.9.5 Out of School Activities

Studies conducted in various countries have brought out the fact that home environment is more important to student learning than school inputs. Providing a home atmosphere conducive to school education is the responsibility of the parents. A parent may not be in a position to help directly in science content. Nevertheless, he/she can motivate the child to undertake relevant tasks. For example, they can

arrange a visit to a zoo and encourage detailed observations of animals. These observations would certainly help children enrich the information that they have gained in school about animals. Similarly, a discussion on why we should switch off the lights and fans when they are not required would bring out the importance of energy conservation that is so empathetically taught in schools. Such practical guidelines are offered to parents in this section.

23.9.6 Identification and Nurture of Talent

Every child is born as an individual. This individuality can hardly be maintained in school system. The mass education system that we follow in the country treats all on equal footing and wants to teach the same content to all with the expectation that outcome of learning would also be same for all the students. The responsibility of identifying individual talent and nurturing it, therefore, falls on the shoulders of parents. In these days of rat race, marks in the examinations are considered to be the sole criterion of success. Remembering and reproducing information in a given time is certainly a skill worth reckoning. But, it is not the only skill human beings can boast of. Giving importance only to examination scores and forcing the students for that actually kills the talent of other kinds. The research in educational psychology has clearly shown that human being display multiple intelligences. The inputs regarding the identification of intelligence possessed by the child are given in this section. In addition to the identification, it is equally important to nurture the talent by creating suitable opportunities to foster it. Useful guidance in this regard is given to the parents through this section. For example, if a candidate has an inclination towards painting then he/she needs to be encouraged to paint by providing him/her with the requisite materials.

23.10 Common Resources

Whether the person registers as a student, a teacher or a parent, a section on common resources is seen by them all along with the resources meant specifically for them. These resources are of four types: (1) Life Sketches of Scientists, (2) Answers to Questions, (3) Published articles, (4) Open forum. Users have an option of choosing any of these folders. Information provided in each of the folders is outlined below.

23.10.1 Life Sketches of Scientists

The folder on life sketches of scientists gives information about the work of some of the great personalities in science who have contributed to the growth of this

discipline. Science is a multinational subject; scientists from different parts of the world have contributed to its development. The number of such persons is quite large and it is almost impossible to give information about all of them. Instead, an attempt is made to refer to scientists whose names appear in the school textbooks. In doing so, focus is kept on the biography of scientists highlighting how they have overcome difficulties and achieved success. In addition, an attempt is made to highlight method of science used by these scientists in their work.

23.10.2 Answers to Questions

This folder includes answers to questions commonly raised by students (Lagu 1978). An attempt is made to provide answers in a simple language without using technical jargon. For convenience, answers to questions are divided into four parts: physics, chemistry, biology and miscellaneous. All those questions that relate directly to the content of school physics are included in the first category. Similarly, the questions that are dependent on school chemistry are included in the second category. Human body is the object of great curiosity for everyone. Moreover, a large number of questions are received about plants and animals around us (Agarkar 1998). All these questions are discussed under the subsection on biology. The questions that cannot be put in any one of the disciplines of science are placed under the fourth category entitled 'miscellaneous'.

23.10.3 Published Articles

School education is a subject of concern for all in the society. Many of them write articles to express their views. It was thought appropriate to get some of the relevant articles to put them on the website. Since only a few articles were available in digital forms, others had to be converted into this format before uploading. In some cases articles had to be scanned and uploaded. For convenience, they are divided into three parts: (1) Articles for students. (2) Articles for teachers and (3) Articles for parents taking into account their relevance.

23.10.4 Open Forum

As a part of open educational resources, a platform has been created for sharing of ideas and experiences among teacher, teacher educators, parents, research workers, educational administrators and school inspectors. The forum, thus, provides an opportunity for exchange of ideas and experiences among all those who are concerned with school education. This platform, named 'Open Forum', forms an

important part of the OER website that enables all the stakeholders to know what is going on elsewhere and to communicate with each other. In the initial phases, material received from teachers, teacher educators and researchers is included in the folder. This main folder has two subfolders, namely exchange of ideas and useful information. The first subfolder aims at compiling first hand experiences of practising teachers while the second subfolder aims at providing information relevant to augmenting school teaching in science, e.g. information about institutions and organisations, information about scholarships, competitions and events like conferences or seminars.

23.11 Field Testing

23.11.1 Identification of Educational Institutions

With a view to field test Open Educational Resources developed through the project two educational systems in the state of Maharashtra were identified. One of them was Rayat Shikshan Sanstha with headquarters at Satara in western Maharashtra. Established by a well-known social worker Mr. Karmaveer Bhaurao Patil, the system has more than 100 schools spread over 11 revenue districts of the state. These schools cater mainly to rural as well disadvantaged groups of students. Another system that was identified for the field testing was Shivaji Shikshan Sanstha with its headquarters at Amravati. Established by another famous educationalist Mr. Panajabrao Deshmukh, these schools cater to the needs of students in Vidarbha region of the state of Maharashtra. This system is also quite large with more than 100 schools spread in about eight revenue districts of the state. Cooperation was sought from these societies by explaining the concept of Open Educational Resources for Schools (OER4S) in regional languages and its role to bring about qualitative changes in school education. Requests were made to the management of both educational societies to send a group of science teachers for training to HBCSE. Moreover, decision-makers were convinced to make available the computers with Internet connections to science teachers.

23.11.2 Workshops for Science Teachers

Around a hundred science teachers, each from the two educational societies were invited for a workshop at HBCSE. During these workshops, the teachers were familiarised with the website containing OER. After giving them instructions on how to access the OER, they were given an opportunity to actually see and download them. Apart from resources made for teachers, they were acquainted with the resources for students and parents and also with common resources designed for all stakeholders. Within a span of three days they were trained to acquire adequate

skills to locate and download the resources they wanted. With a view to reach to a larger number of practising teachers, additional training courses were conducted in schools. Since both the education systems identified for field testing were very huge and cover many districts, these workshops had to be arranged in different regions. Suitable places with computing facilities were identified for conducting these workshops. Teachers were acquainted with the website and given inputs on how to access the resource of their choice. Adequate practice sessions were arranged so that they gain enough confidence to locate and use OER in the classroom.

23.11.3 School Visits

Visits were made to schools of teachers who were chosen for the field testing of OER. Through the workshops conducted at HBCSE and at various other places in the state, the teachers were familiarised with the OER website. After going back into the system, they tried to access it. However, many of them could not access the website as their schools did not have Internet facility. To overcome this problem OER were provided on compact discs to interested teachers. The experience of using OER by these teachers has been positive.

Apart from school teachers, resources were designed for parents also. Our contact point was a school teacher and we expected to approach parents through them. This idea did not seem to work well. There has been a limited interaction between teachers and parents. Parents come to school when their kids have problems or when there is a meeting of teacher parent association. These interactions are inadequate to pass on the message of OER for parents and to create confidence among them to access them. Additional efforts had to be made to sensitise parents towards the use of OER for the benefit of their children and get feedback from them. The project team attempted to contact a few parents during school visits with some success.

23.11.4 Feedback Received

During the workshops held at HBCSE, an attempt was made to get the opinions of teachers about the resources. A questionnaire was designed to seek relevant information from them. It had two parts: the first part sought personal information about the teacher along with their knowledge of computer and use of the Internet while the second part sought their opinions about OER on the website. Analysis of the data collected through the first part of the questionnaire revealed the following.

1. Computers are making headway in schools. Nonetheless, exposure to the use of computers is very limited for practising teachers. A majority of teachers are still unfamiliar with terms like PowerPoint, pdf, Page-maker, Photoshop, Coral Draw, etc.

2. A large number of teachers have registered for a course called MS-CIT (Maharashtra State Course in Information Technology) implemented by MKCL all over the state of Maharashtra. Many of them have completed the course. However, only a few teachers have the confidence to handle computers effectively.
3. The teachers were familiar with the word Internet as it is used in railway reservations and other activities. However, teachers hardly have competence in locating a particular website for their use. Only about 10 per cent of the teachers had their own email addresses.
4. For a majority of teachers, prescribed subject textbooks were sufficient for teaching school science. They did not see the need to look for any additional material or different mode of interactions in classroom proceedings.
5. Teachers are sceptical about how the use of computer and the Internet will improve the scholastic performance of their students. For a majority of teachers, scores in the examinations are of utmost importance. In their opinions, computers should be used to enhance examination scores and not to enhance understanding.

As mentioned earlier the second part of the questionnaire focused on teachers' opinion towards OER. Qualitative analysis of the data collected brought out the following.

1. In general all the participants appreciated the task of designing OER in the regional language (Marathi) as no such material is available that focuses on school science education.
2. Teachers liked the idea of designing resources not only for school students and teachers but also for parents. Parents, in their opinions, play a crucial role in shaping the behaviour of children.
3. Teachers looked at the common resources positively. The stories about scientists, they felt, would go a long way in motivating students to opt for science related careers. Similarly, the answers to a large number of questions given on the website, teachers opined, would help satisfy students' curiosity to a great extent. The section that appealed the most was the section on open forum. Since this forum enables the teachers to share their experiences and opinions, they thought the website has provided a space for sharing their ideas and experiences.
4. The website, many of the teachers opined, fulfils the felt needs of students, teachers and parents. Hence, the website would prove useful for all the three stakeholders. However, the culture of using resources beyond the prescribed textbook for school related tasks has yet to be spread in India. It would take time for this culture to take roots. Only then the material made available on the website would be used profusely by all the stakeholders.
5. While appreciating the efforts made by HBCSE, MKCL and I-CONSENT, teachers went further to suggest improvements to enhance their effectiveness. First, they have suggested that the resources should be illustrated using good pictures and cartoons. While giving a positive opinion about OER development, they also suggested that the resources should be such that they can be used directly by the teachers in the classroom or outside the classroom.

6. While applauding the efforts in designing the website, the teacher shared their concern about its use in rural areas due to the lack of reliable Internet facilities. Noting that the internet penetration was improving slowly the teachers emphasised the need to augment the efforts so that every school has a dedicated high speed Internet connection.
7. Teachers also noted that many of their colleagues as well as parents are not confident with using computers. It is, therefore, necessary that programmes should be undertaken to enhance computer literacy among teachers, students and parents.

23.12 Outcomes and Implications

Over the span of six years (2007–2013) the project yielded a large number of Open Educational Resources. These resources have been prepared taking into account the needs and requirements of school students, their teachers and parents. More importantly, these resources are made available in the regional language (Marathi), which is the medium of instructions for the majority of schools in the state of Maharashtra. This project has, thus, fulfilled the long felt need of supporting material in regional languages (Kulkarni et al. 1994). It is hoped that these resources would enable to meet the diverse needs of the school system in India.

The feedback received from the teachers, students as well as parents on the OER made available on the website is quite positive. All of them appreciated them and opined that they will certainly help improve teaching learning in the schools of the state of Maharashtra. There is, therefore, a ground to hope that this movement of open educational resources would take roots in the state of Maharashtra and eventually spread to the entire country soon.

A selected group of teachers from all over the state was invited to participate in the resource generation workshops. Moreover, arrangements were made for a large number of practising teachers to field test the resources. The project has, thus, created a network of about 1500 teachers. Some of them have a good flair of writing and are willing to contribute OER units. They can be encouraged to continue preparing OER in the future and realise the dream put forth by National Knowledge Commission (Takwale 2009).

Four different organisations came together to undertake the task of designing OER for schools. Rajiv Gandhi Science and Technology Commission, a state government organisation, made available funding required for the project. The implementation of the project was undertaken by three different organisations, namely HBCSE, MKCL and I-CONSENT. Roles of these organisations were clearly defined since the beginning of the project. HBCSE, being a research institution in science and mathematics education, undertook the responsibility of developing, digitising and uploading the resources using Content Development and Integration Tools (CDIT). MKCL, being a company in the Information Technology

sector, undertook the responsibility of designing and maintaining the website. I-CONSENT, a voluntary organisation, mobilised the resources of different institutions. Thus, the collaborative model of working together for a common cause in improving quality of school education was proven successful. Such a model can be replicated anywhere in the world.

It must be realised that mere development of OER and uploading them to the website will not achieve the expected impact. There is a need to create awareness about these resources among the end users. At the same time they need to be convinced that these resources are useful to them. Awareness campaigns and personal contacts are required to spread the movement of OER. It is a fact that dedicated Internet connections are not available in many schools in rural areas. The task of providing this facility should be undertaken on a priority basis. Until such a facility is created digital resources should be made available through CDs and hard discs. The culture of designing and using open educational resources in the country would certainly lead to citizens capable of informed decision-making and sustainable problem solving.

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Appendix: Resources for Students

Primary Level

1. Our Earth
   (a) Day and Night
   (b) Seasons
   (c) Eclipses
   (d) Land and Oceans

2. Our Atmosphere

   (a) Components of atmosphere
   (b) Atmospheric Pressure
   (c) Changes in Atmosphere
   (d) Crops in Different Atmosphere

3. Our Body

   (a) Parts of Our body
   (b) Sense Organs
   (c) Body Coordination
   (d) Caring Our Body

4. Our Food

   (a) Types of food
   (b) Digestion of food
   (c) Balanced Diet
   (d) Preservation of Food

5. Our Material World

   (a) Sates of Matter
   (b) Properties of matter
   (c) Common substances (Water, Oxygen, etc.)
   (d) Natural and man-made substances

6. Our Living World

   (a) Living and nonliving
   (b) Animals
   (c) Plants
   (d) Uses of animals and plants

7. Our World of Work

   (a) Types of energy
   (b) Sources of energy
   (c) Work and Energy
   (d) Simple machines

Upper Primary Level

1. Earth and heavenly bodies

   (a) Our Earth
   (b) Sun and Stars
   (c) Eclipses
   (d) Atmosphere

2. Resources

   (a) Natural resources
   (b) Renewable and non-renewable
   (c) Fossil fuels
   (d) Judicious use of fuels

3. Energy

   (a) Energy sources
   (b) Conversion of energy
   (c) Energy crises
   (d) Fuels

4. Environment

   (a) Biotic and abiotic components
   (b) Environmental degradation
   (c) Pollution control
   (d) Clean environment

5. Matter

   (a) Classification of matter
   (b) Physical and chemical changes
   (c) Metals and non-metals
   (d) Useful compounds

6. Living World

   (a) Living and nonliving
   (b) Plants and animals
   (c) Adaptation of living beings
   (d) Reproduction

7. Health and Hygiene

   (a) Diseases and their control
   (b) Nutrition
   (c) Hygienic practices
   (d) Community health

Secondary Level

1. Living Word

   (a) Cell: Structure and function
   (b) Organisation
   (c) Classification
   (d) Life processes

(e) Microorganisms
(f) Evolution
(g) Adaptation

2. Human body

(a) Respiratory system
(b) Excretory system
(c) Circulatory system
(d) Reproductive system
(e) Digestive system
(f) Nervous system
(g) Endocrine system
(h) Lymphatic system

3. Health and Hygiene

(a) Nutrition, balanced diet
(b) Deficiency/Over-intake diseases
(c) Infectious diseases
(d) Genetic disorders
(e) Diseases due to malfunctioning of body organs
(f) Community health
(g) Hygienic practices

4. Environment

(a) Biodiversity
(b) Conservation
(c) Environmental pollution
(d) Resources and their conservation
(e) Ecology/ecosystem
(f) Climate change
(g) Sustainable development

5. Agriculture

(a) Food (production, preservation, spoilage and adulteration)
(b) Soil and its conservation
(c) Agricultural management
(d) Supporting activities (fisheries, sericulture, poultry, etc.)
(e) Modern agricultural techniques
(f) Insecticides/pesticides
(g) Fertilisers

6. Study of Matters

(a) States of matter
(b) Classification of matter (elements, compounds and mixtures)
(c) Methods of separation

(d) Metals, non-metals
(e) Some common substances
(f) Acids, bases and salts
(g) Atomicity of substances

7. Structure of Atom

(a) Dalton's theory of atom
(b) Discovery of atomic particles
(c) Particle distribution in atom
(d) Electronic configuration
(e) Valency and valence electrons
(f) Reactivity and bond formation

8. Elements and their Classification

(a) Idea of elements
(b) Atomic number and atomic weight
(c) Early efforts of classification
(d) Mendeleev's periodic table
(e) Modern periodic table
(f) Relation between periodicity and electronic configuration
(g) Isotopes
(h) Application of periodic classification

9. Chemical reactions and equations

(a) Physical and chemical changes
(b) Types of chemical reactions
(c) Factors affecting rate of reaction
(d) Symbols of elements and formulae of compounds
(e) Chemical equations
(f) Energetics in chemical reaction

10. Solutions

(a) Formation of solution
(b) Types of solutions
(c) Molarity and normality
(d) Neutralisation
(e) Precipitation
(f) Solubility
(g) Electrolytic solutions
(h) Arrhenius theory
(i) Colloidal solutions

11. Metallurgy

(a) Common metallurgical processes
(b) Extraction of metals (Iron, Copper and Aluminium)

(c) Extraction of non-metal (Sulphur)
(d) Study of compounds of metals and non-metals
(e) Alloys
(f) Manifold uses of metals and their alloys

12. Mole Concept and Stoichiometry

(a) Concept of mole
(b) Gas laws
(c) Gas equation
(d) Avagadro's hypothesis
(e) Problems associated with mole
(f) Calculations based on chemical equations

13. Carbon compounds

(a) Characteristics of carbon compounds
(b) Bonding in carbon compounds
(c) Aliphatic hydrocarbons
(d) Aromatic hydrocarbons
(e) Petrochemicals
(f) Common carbon compounds

14. Energy

(a) Sources of energy
(b) Types of energy
(c) Energy conversion
(d) Units of energy
(e) Work
(f) Power
(g) Energy crises

15. Mechanics

(a) Motion and its types
(b) Speed, velocity and displacement
(c) Scalar and vector quantities
(d) Laws of motion
(e) Equations of motion
(f) Forces and their types
(g) Inertia
(h) Momentum and its conservation
(i) Force and pressure

16. Optics

(a) Propagation of light
(b) Scattering of light
(c) Reflection of light

(d) Refraction of light
(e) Dispersion of light
(f) Ray diagrams
(g) Magnification and magnifying power
(h) Optical devices
(i) Human eye
(j) Electromagnetic spectrum

17. Heat

(a) Generation and transmission of heat
(b) Measurement of heat
(c) Temperature and its measurement
(d) Specific heat of substances
(e) Latent heat
(f) Effect of heat (water, metals)
(g) Melting and boiling points
(h) Dew points and moisture

18. Sound

(a) Production of sound
(b) Propagation of sound
(c) Reflection of sound
(d) Echo and its application
(e) Speed of sound
(f) Loudness and pitch
(g) Musical instruments
(h) Hyman ear
(i) Sound pollution

19. Electricity

(a) Static electricity
(b) Electroscopes
(c) Electric charge and field
(d) Current electricity
(e) Electric circuits
(f) Ohms law
(g) Electrical cells
(h) Effect of electricity
(i) Uses of electricity

20. Magnetism

(a) Magnets and their properties
(b) Magnetic field and lines of forces
(c) Electromagnet
(d) Electromagnetic induction

(e) Uses of magnets
(f) DC and AC generators

21. Radioactivity

(a) History of radioactivity
(b) Radioactive substances
(c) Types of radiation
(d) Law of radioactivity
(e) Half-life period
(f) Fission and fusion processes
(g) Nuclear reactions
(h) Atomic energy
(i) Radioactive hazard
(j) Uses of radioactive isotopes

22. Technology and Human Life

(a) Technology and development
(b) Biotechnology
(c) Communication technology
(d) Chemical technology
(e) Nanotechnology
(f) Information technology
(g) Genetic engineering
(h) Space technology

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