Project Report on

EkShiksha-Chemistry

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Submitted in fulfillment of internship project

By-

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Lastly, we thank all those who were involved directly or indirectly in the successful completion of the project work.

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ABSTRACT

Three-dimensional (3D) animations, today are one of the most modern resources for teaching Chemistry and learning. They can be visualized in any part of the world via the internet with desktop computers, tablets, and smartphones. They are among the newest teaching aids to be researched on and developed to enhance the learning experience of students. The difficulty of students to visualize three-dimensional structures has always been pointed out by teachers as one of the main problems in learning Chemistry. This difficulty in visualization is attributed to the limited resources that teachers traditionally have, to represent the three-dimensional structures in various concepts: chalk, blackboard, and overhead projector.

By teaching Chemistry through the use of three-dimensional animations, we seek to help students create three dimensional images with movement in their minds and explore key concepts with greater ease. The 3D animations stimulate the students' capacity for abstraction and facilitate visualization of three-dimensional conceptual models, promoting the same level of learning for everyone. Several concepts like atomic structure, chemical bonding, crystal lattices, hybridisation in organic molecules, which require great capacity for abstraction and three-dimensional visualization, are some examples of concepts that can be taught using 3D animations.

TABLE OF CONTENTS

1. INTRODUCTION

The digital information era offers a huge amount of multimedia-based educational resources, such as software modeling and 3D animation of molecules, tutorials and simulators. Several studies and surveys have shown that the proper use of these features may enhance the understanding of core concepts and improve the overall learning experience of students.

1.1 Purpose

The main aim of our project is to explore the usage of animations to facilitate better understanding of Chemistry concepts. We seek to achieve this aim by providing a platform where students can observe, explore and understand different topics through the use of 3D animations created using Three.js library along with relevant chemical data stored in a database.

1.2 Project Scope

The purpose of this project is to create convenient and easy-to-use interactive web application for teachers and students to teach and learn concepts like Atomic Structure, Photochemistry, VSEPR Theory, Lattice structures, Hybridization of Orbitals and Organic reactions. Thorough this application, we hope to provide a comfortable user experience along with maximum learning and retaining of concepts.

1.3 Intended Audience

This project is meant for students learning Chemistry between class 9 and 12 who want to learn chemistry concepts in an interactive and animated setting.

2. DESCRIPTION

2.1 Users
The system will support two types of users-Teachers and Students. Teachers will have the rights to add new chemical knowledge and both teachers and students will have the rights to view the animations and learn concepts.

2.2 Operating Environment
Client/server system
Database: MySQL
Platform: Web page
Browser: All browsers which support HTML5, CSS, JavaScript and WebGL.
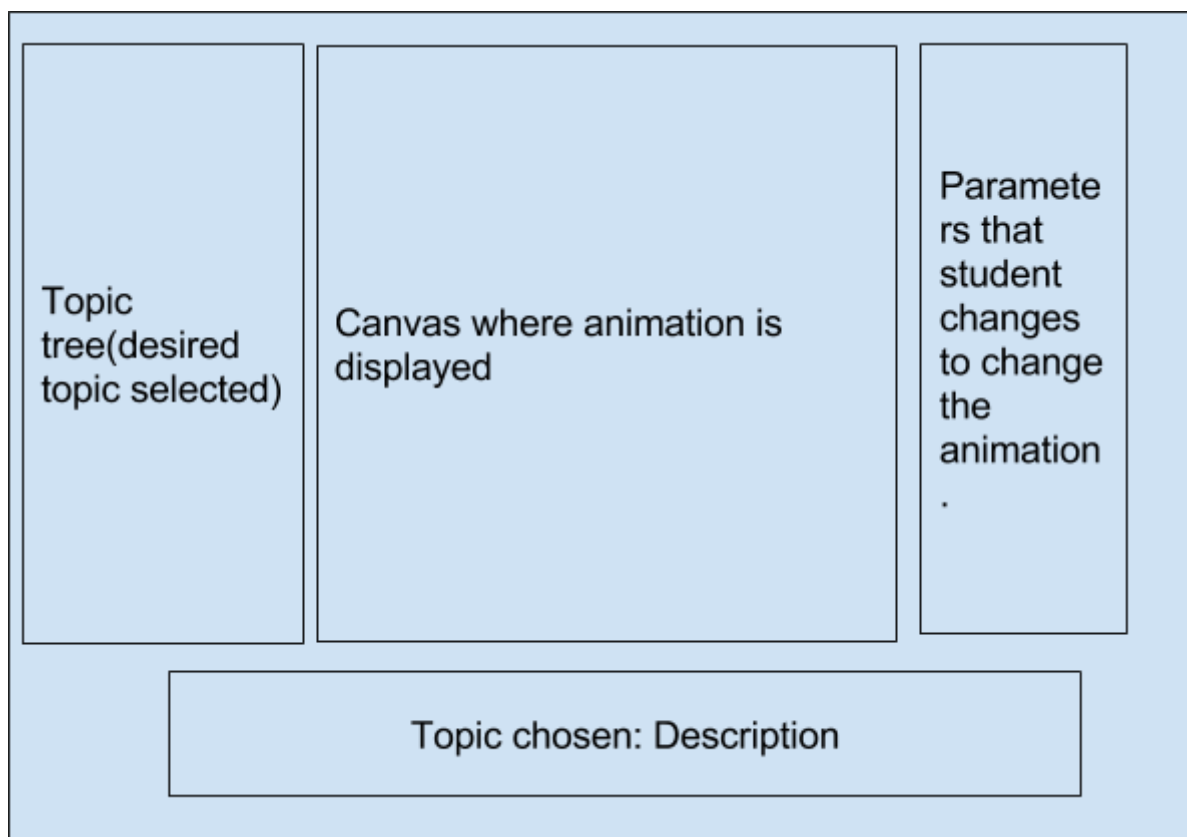
3. SPECIFICATION AND DESIGN

The web application contains animations and concepts on the following topics:

- Structure of an atom
    Atomic view
    Photochemistry
- Chemical Bonding
    VSEPR Theory
- Solid state
    Lattice Structures
- Chemical reactions

    Combination Reaction
        Decomposition Reaction
            Single Displacement Reaction
            Double Displacement Reaction
- Hybridization of Orbitals
        Hydrocarbons
- Organic Reactions
        Substitution Nucleophilic Reaction Unimolecular(SN1)
        Substitution Nucleophilic Reaction Bimolecular(SN2)

3.1 User Interface

Two types of users are supported by the application.

3.1.1 Students' view:

| Topic tree(desired topic selected)	Canvas where animation is displayed	Parameters that student changes to change the animation.
	Topic chosen: Description	

3.1.2 Teacher's' view:

The teachers' view is similar to the students' view but a ⊕ symbol is present next to certain topics allowing the teacher to input chemical data to generate more animations.

The student and the teacher can view animations by selecting the desired topic from the topic tree and varying parameters in the sidebar on the right side of the screen.

3.2 System Interface/Integration
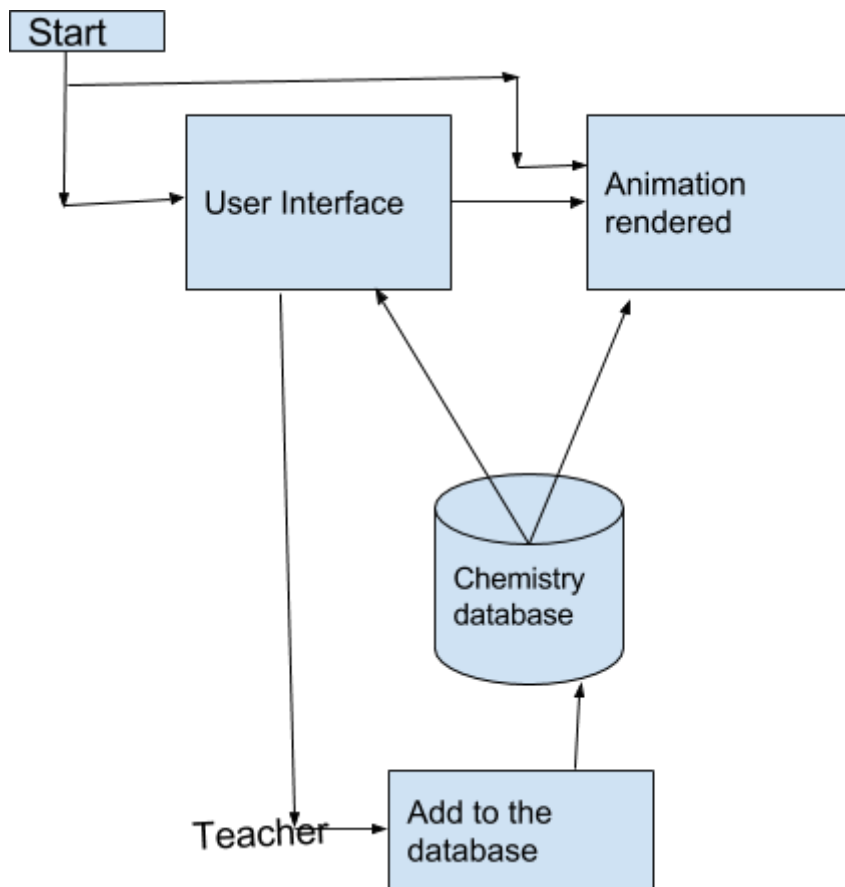
The complete database schema of the different databases are present in Appendix A: Chemistry Schema

4. Implementation

The project was implemented by creating a **DB-to-Animations Framework** through which all required chemical data was added to a database. Every table in the database represents a new topic and each row of the table represents a different animation.

New animations can be created easily by updating the database and new topics can be added to the application by creating new tables.
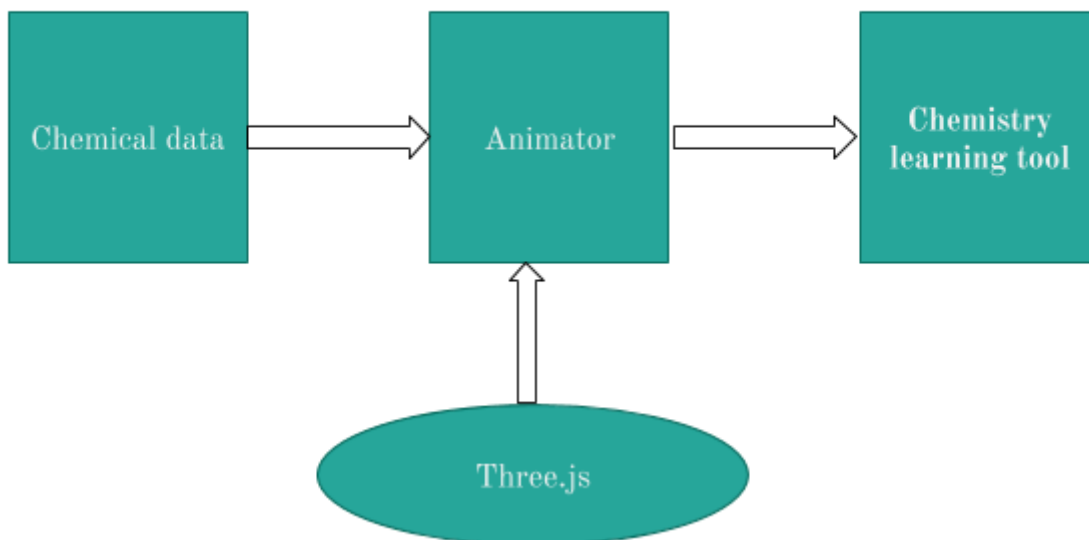
The web application is created using the following technologies:

4.1 Technologies used

Front-end software: HTML,CSS, Javascript, Bootstrap
Back-end software: Java, JSP
Database: MySQL
Technology for animations: Three.js

4.2 Requirements

Browser which supports WebGL, HTML & Javascript.

4.3 Metrics

Animation aspects

Topics	Objects/Views	Methods	Lines of code	Tables in database
Structure of an Atom	5	6	215	1
Chemical bonding	21	8	311	2
Solid state	14	9	206	2
Chemical reactions	8	11	377	4
Hybridization	4	11	456	2
Organic reactions	4	3	346	2
Total	56	48	1911	13

Application aspects

Topics	Objects	DAO	Servlets	Methods	Lines of code
Structure of an Atom	1	2	2	3	409
Chemical bonding	0	1	1	7	269
Solid state	1	3	1	8	415
Chemical reactions	3	8	8	4	1313
Hybridization	1	2	2	6	131
Organic reactions	0	2	2	6	120
Total	6	18	16	34	2657

No. of lines of code: ~7000

5.TOPICS COVERED

The following topics were covered by us in our project.

5.1 Structure of an atom

The topic **Structure of an atom** is divided in two subtopics:

Atomic view:

This topic has the following features:

- The properties of any atom (name,symbol, type and electronic configuration) can be viewed (as a hint) by entering its atomic number in the provided input box**.** The atom can also be viewed in 3 different views: Full View(atom with the complete nucleus and electron), Electron view(view showing only electronic configuration) and Valence shell view(view showing only the valence electrons), by selecting the desired view.

- The complete periodic table can be viewed by clicking on the periodic table button. On the periodic table, the properties of different elements can be viewed by hovering on them. Clicking on any element opens its atomic view, where the atom can be viewed in 3 different views(similar as before).

Photochemistry:

This topic is meant for showing the excitation and de-excitation of electrons from one energy level to another. The initial and final energy level of the electron can be specified in the input boxes. The animation demonstrates the absorption and emission of photons necessary for excitation and de-excitation of the electron respectively. The energy absorbed or emitted is also displayed.

5.2 Chemical Bonding

The topic Chemical Bonding contains the subtopic VSEPR Theory.
This topic has the following features:

- 3-Dimensional structures of different compounds(Eg: BeCl2,BF3,BCl3,CH4 etc) stored in the database can be viewed by selecting the compound from a dropdown menu.

- Different generic geometries of compounds, namely Linear, Trigonal Planar, Tetrahedral, Trigonal Bipyramidal, Octahedral, Pentagonal Bipyramidal can be viewed by selecting the geometry from the list.

- New compounds can be added to the database by clicking on the ⊕ button and filling in the details(name, total number of electron pairs and number of lone pairs) for the new compound.

- The shape of the molecule being viewed can be seen by hovering over the hint button.

5.3 Solid State

The topic Chemical Bonding contains the subtopic Lattice Structures.
This topic has the following features:

- Lattice structures of different compounds(Eg: NaCl,Cu,TiO2 etc) stored in the database can be viewed by selecting the compound from a dropdown menu.

- 14 Different crystal lattices can be viewed by selecting one of the seven crystal structures namely Cubic, Tetragonal, Orthorhombic, Hexagonal, Monoclinic, Triclinic, Rhombohedral and selecting the required Bravais lattice.

- New compounds can be added to the database by clicking on the ⊕ button and filling in the details(name and lattice type) for the new compound.

- The properties of the crystal lattice being viewed can be seen by hovering over the hint button.

5.4 Chemical Reactions

Different reactions are stored in the database, and the animations depend on the stored parameters. The topic **Chemical Reactions** is divided in four subtopics:
Combination reactions
Decomposition reactions
Displacement reactions
Double Displacement reactions

- These four subtopics have the following common features:

- A generic animation of the type of reaction selected can be view by clicking on the ⊙ button.

- An example animation can be viewed on clicking the show button.

- Any of the reactions stored in the database can be viewed by selecting the different reactants.

- More reactions can be added to the database by clicking on the ⊕ button present above the topic heading, and inputting the necessary data.

5.5 Hybridization

The topic Hybridization contains the subtopic Hydrocarbons.
This topic has the following features:

- Structure of various hydrocarbons can be viewed on choosing one compound from the drop down menu.
- 3-Dimensional animation of the hybridization of orbitals in different hydrocarbons(Eg: Alkanes,Alkenes,Alkynes) can be viewed by selecting the hydrocarbon from a dropdown menu.
- The properties of hydrocarbon (name, hybrid type, atomic orbitals, angle, spatial arrangement and shape) can be viewed (as a hint) by selecting the particular hydrocarbon from the drop down menu**.**

- New compounds can be added to the database by clicking on the ⊕ button and filling in the details(name ,type of hydrocarbon and the position of double or triple bond in the new compound).

5.6 Organic reactions

The topic **Organic reactions** is divided in two subtopics:
Substitution Nucleophilic Unimolecular Reactions(SN1) and
Substitution Nucleophilic Bimolecular Reactions(SN2)

- Mechanism of the reactions stored in the database can be viewed by selecting the different reactants from the drop down menu.
- The reactants and the products for the selected reaction are displayed in the tooltip.
- The knowledge of the groups attached to the carbon atom(Leaving group, Adding group, etc) is also displayed.

- More reactions can be added to the database by clicking on the ⊕ button present above the topic heading, and inputting the necessary data.

6.CHALLENGES & LEARNING

The internship proved to be a great opportunity to experiment and learn a multitude of new things even though some challenges were faced.

A few challenges were faced while

- Working with many new technologies
- Managing version and maintaining code
- Managing the database

We also learnt many technologies such as

- Three.js library
- Java technologies and concepts
- MySQL database
- Web development

And social skills such as

- Team work
- Collaborative skills

7.FEEDBACK

A survey was conducted among 40 students aged 12 and above regarding their views on the use of 3D animations to enhance understanding in Chemistry. The responses are as follows:
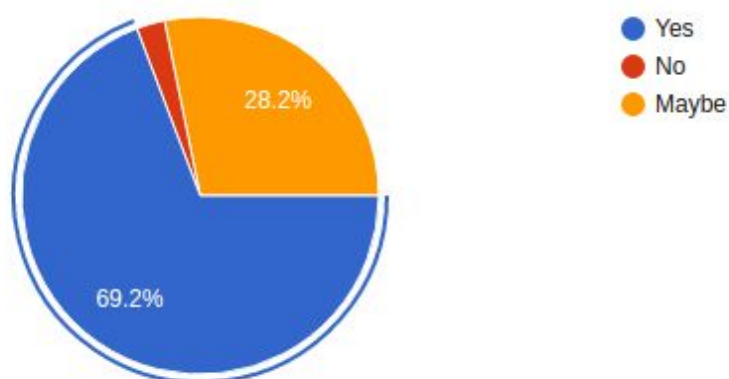
Q. Do you believe that the use of animations can enhance learning experience in any subject?
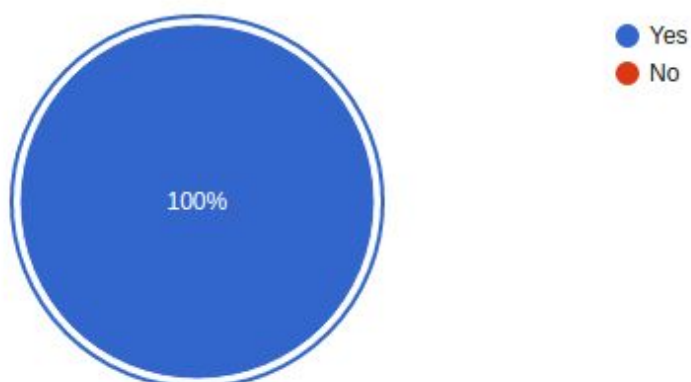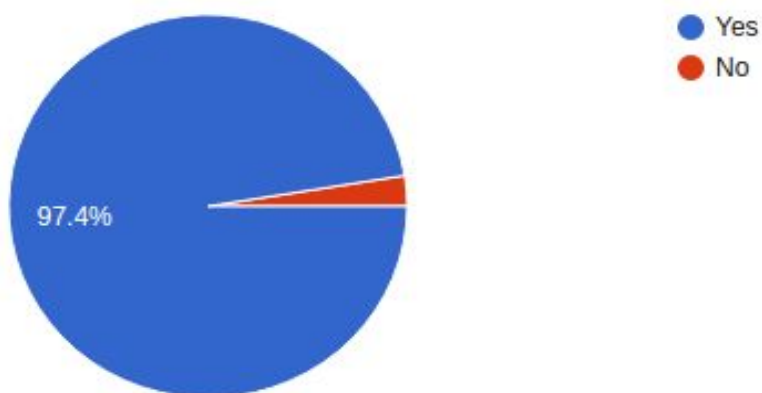
Q. How often do you use animations to learn key concepts?
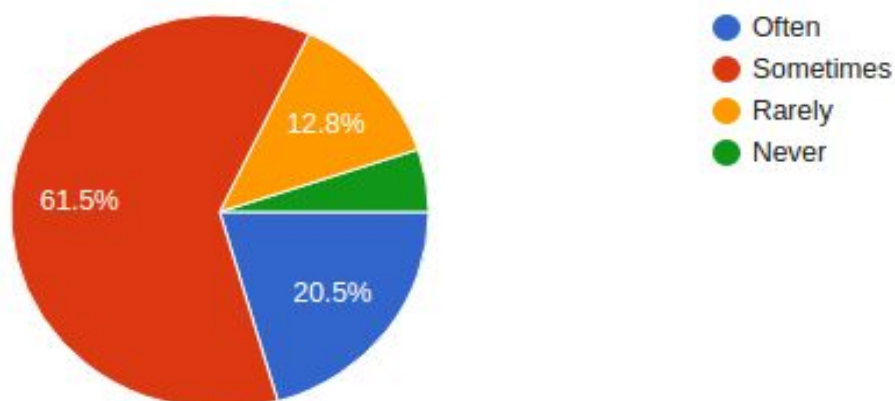
Q. Would you like to use a website especially meant to instill concepts of Chemistry better through 3D animations?

Q. Would you prefer to learn using controllable animations (that can be clicked, dragged, zoomed etc) over videos and 2D tools?

Q. What mode of learning would you feel most comfortable with?

- Chalk and talk : **53.8%**
- Presentations : **25.6%**
- Audio and video clips : **46.2%**
- Physical models : **25.6%**
- 3D animations : **66.7%**
- Other : **5.2%**

From the feedback, it is evident that students not only will be greatly benefitted by the existence of a good animation framework for Chemistry, but that a great scope for further improvement also exists.

8.RESULT

The web-application was developed and tested for all the concepts. Feedbacks were done to get an insight into the future scope and development of the project.

9.FUTURE WORK

The existing framework can be extended to add more views to existing objects and can be appropriately used in certain other concepts which include :

- Surface Chemistry and polymers
- Extended concepts in Organic Chemistry
- Optical Chemistry
- Bio-Chemistry

New topics can be added by adding appropriate tables to the database, and new animations can be represented as entries in the tables.

10.CONCLUSIONS

Most of the aims of the project were met. A web-application was developed that could be accessed by anyone via the internet with desktop computers, tablets, and smartphones. The application provides an enhanced learning experience to students in various topics in Chemistry spanning classes 9th to 12th and also has the scope for major developments in the near future.

11. REFERENCES

Thesis: "DEVELOPMENT AND UTILIZATION OF 3D ANIMATIONS IN CHEMISTRY TEACHING" , 2013, State University of Campinas

NCERT Textbooks, Class 9th-12th

12. APPENDIX

Appendix A. Chemistry schema Database schema for the Chemistry database.