Development and Validation of Teaching Chemistry by using Mathematics Lab Package

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Abstract:

This study examined the impact of Teaching Chemistry by using Mathematics lab components. This experiment was conducted on Secondary School Students. This package consists of 22 interdisciplinary Concepts of Chemistry and Mathematics. Twenty-Six lesson plans arebased on Constructivism Theory. Researcher used the lesson Plans are based on Constructive Theory by using 5E model. In this package researcher used Laboratory, Demonstration, Observation and other conventional methods to teach Chemistry by using Mathematics Lab. Pilot study was done in a renowned High School in Shivamogga, Karnataka was done for about three months. During the pilot study researcher by introspection and also by the student's feedback modified the Lesson Plans accordingly. Package is validated by the Subject experts, Educationists and teachers. Materials used for teaching learning process include Mathematical Lab components, Charts, audios, Videos and Flash cards. Reliability of the package was established.

Key words: Teaching Chemistry, Mathematics Lab, Package

➢ Introduction

Mathematical ability is a major contributory factor to the academic success of a student in any science course. To determine the source of the difficulty that students often find while performing calculations in chemistry. Through the design and analysis of a set of chemistry questions and analogous mathematics questions, set in a Standard Grade context, it is revealed that a basic grasp of mathematics is missing. The importance of mathematical ability as applied to chemical education has recently gained much attention due to both the chemical industry and academia having commented on students' poor grasp thereof (Royal Society of Chemistry, 2009a). This has led to the development of a number of different initiatives and resources by the Royal Society of Chemistry, and collaborators, in order to ameliorate the situation (Royal Society of Chemistry, 2009b–c). With such a significant impact on the chemical sciences, and more broadly the scientific community as a whole, it would seem prudent to further investigate the origin of such difficulties that students display in carrying out chemical calculations, the investigator has designed the lessons which teaches Chemistry by using mathematics knowledge.

Chemistry is a bridge to many other natural sciences. It is, for that reason, no surprise that mathematics plays a huge role in chemistry. As Quinn states, mathematic skills can be transferred to science courses. Chemistry is filled with math. Constants, temperatures, equations, and time are all parts of chemistry that require mathematics. Skills such as rounding, order of operations, and scientific notation are all essential to the basic properties of chemistry. Reading graphs and calculating slope, as would be done in a course such as geometry, is also a mathematic skill that is frequently used in.

The ability for a student to be able to use their mathematics knowledge for chemistry is crucial for the student to succeed in chemistry. Math skills also boost students' confidence levels in science classes since much of the science class is based on math. Chemistry without mathematics is impossible. The need for students to be able to use critical thinking, verbal reasoning, and mathematics all together in chemistry courses is a great reason that new teaching methods are best implemented by qualified chemistry teachers. Laboratory experiences have been reported to promote central science education goals including the enhancement of students' understanding of concepts in science and its applications; scientific practical skills and problem solving abilities; scientific 'habits of mind'; understanding of how science and scientists work; interest and motivation(Hamidu M. Y., Ibrahim A. I., Mohammed A, 2014),so it is need of the hour to adopt new strategies for teaching. Many students leave high school chemistry courses with profound misunderstandings about the nature of matter, chemical processes and chemical systems.(Patricia Schank& Robert Kozma, 2002) and it is necessary to teach chemistry by using Interdisciplinary approach of Chemistry and Mathematics.

➢ Significance of the study

In chemistry it is often necessary to apply mathematical terms, methods and scientific paradigms in order to explain chemical phenomena. Furthermore, a mathematical analysis of chemical processes can help to facilitate and deepen the understanding of the underlying chemistry. That is why avoiding mathematical views in chemistry lessons might result in students having difficulties in developing an adequate understanding of chemistry. On the other hand, it is known that students have difficulties with connecting aspects of mathematics with chemistry. Mathematics is an essential skill for chemistry students to master. Students with solid backgrounds in both mathematics and chemistry have many good options. They would be strong candidates for graduate programs in mathematics, applied mathematics, statistics, biostatistics, chemistry, crystallography, biochemistry, molecular biology, physics, biophysics, computer science, public health, epidemiology, and bioinformatics. In addition, these students would be desirable to medical schools and law schools.

➢ Development of the Teaching Chemistrythrough Mathematics Lab Package consists of following factors

- Content and activities are flexible for teachers to suit the situation.
- Keeps the interest and motivation among the students throughout the programme.
- Provision to continuous and Comprehensive evaluation
- Activities can be performed by the Students on their own with the instructions.
- Materials used are cost effective and available readily within the local environment
- Active use of process skills of observation, classification and inference was facilitated.
- Provisions for self-learning and self-experiments.
- Can be readily used by the teachers readily.

➢ Procedure Followed to DevelopTeaching Chemistrythrough Mathematics Lab Package:

The steps followed for Construction and Standardization of Teaching Chemistrythrough Mathematics Lab Packageare as follows.

1. Planning
2. Preparation of Lesson Plan
3. Pilot Study
4. Establishing Validity and reliability.

- **Planning:**The content analysis of the texts of Science and Mathematics of secondary classes was done to check for the adequacy and relevance for developing Teaching Chemistrythrough Mathematics Lab Package**.**Written the instructional objectives and the contents. the materials were analysed and teaching techniques are chosen.This package is used for class 10 students. About twenty-two Concepts of interrelated Mathematics and Chemistry were chosen. Before writing lesson plan possibility of Connecting Mathematics Lab with Chemistry was checked by visiting Mathematics lab in Secondary Schools. Opinions and guidelines from Mathematics teachers using mathematics lab was taken and also possibility of interdisciplinary approach between mathematics Lab and other subjects were discussed. Written the instructional objectives and the contents, the materials were analysed and the interrelated Chemistry and Mathematics Contents were Chosen. Each concept was taught in classroom and related activity was done in Mathematics lab, number of concepts, division of classes are shown in Table 1

Table1: Selection of Teaching Concepts and Duration:

Sl.No	Mathematical Concept	Chemistry Concept	Number of classes (each class is of 40 minutes)
1	**Algebraic Expression** Algebraic tiles – Algebraic expression – $(a+b)^2 = a^2+2ab+b^2$	• Simple Balance – Principle and its usage • Balancing chemical equation.	3
2	**Geometrical shapes** (single, two- and three-dimension structures) Concept of angles in Geometrical shapes Solid figures – Faces, Edges and vertices	• Geometry of molecules	4
3	**Ratio** To find out the ratio between given numbers	• Calculation of Molar mass of Chemical compound by determining the ratio of elements in the Compound • To find out the mass ratio of elements present in a compound • To find out the ratio of elements present in a compound. • To find out the formula of the compound by knowing the ratios of Elements present in it.	5
4	**Percentage** Use of percentage protractor in finding out percentages	• To find out Volume percent of a solution. • To find out Chemical Formula of Compound by its Empirical Formula	3
5	**BODMAS Rule** To Solve the arithmetic	• To find out Molecular Mass of a compound	2

	sequences by using BODMAS model		
6	**Fraction** Use of Fraction Tiles to find fractions.	• Balancing Chemical Equations by Fraction method • To Find out the Mole Fraction of Compounds.	3
7	**Geometry** Basic terms on Geometrical Concepts.	• The Chemical Formula C_nH_{2n+2} And Its Mathematical Background	6

- **Preparation of Lesson Plan**

About 22 basic teaching Concepts related to Secondary School are considered for developing the package. These concepts are from class 8,9 and 10 of Science and Mathematics textbooks. The concepts are written on the basis of constructivism theory and lesson plans are executed based on activity method which include laboratory method. care is taken so that most of the concepts are learner centred. The lessons are planned in such a way that teacher only acts as a Facilitator while learning is done by students themselves by exploring the concepts. The draft of the package was prepared. Activities and questions were to be posed and feedback material was designed at the end of eachconcept. Lesson plans were designed based on contents for particular period of teaching. Materials required for these activities also were listed out, submitted to the respective subject teachers and eminent experts from the field of education for scrutiny. It was based on their suggestions and the content was modified aptly. Students are free to express their learning. To make learning more interesting and effective they are supported with teaching learning materials which include Audios, Videos, Mathematics Lab equipment's, Charts, Flash cards. The lessons plans were sent to Eight Subject teachers (Mathematics and Chemistry) who are teaching in secondary schools,4 Research experts,4 Subject experts (lecturers of Chemistry and Mathematics).Each lesson plan was planned for 40 minutes class. The lesson plan was based on Constructivism theory using 5E model.

❖ Model lesson Plan

Teaching Concept: Geometry of molecules

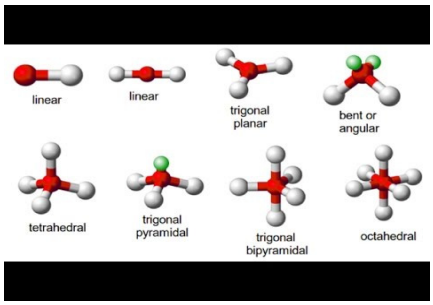
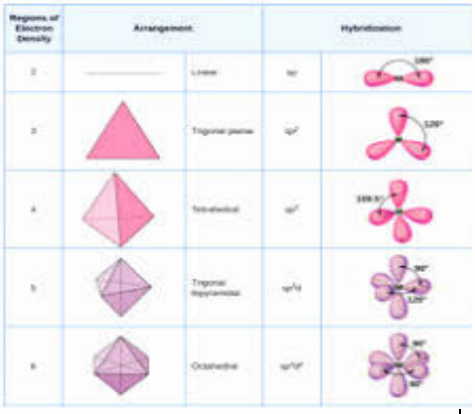
Learning objectives: Students are able to,

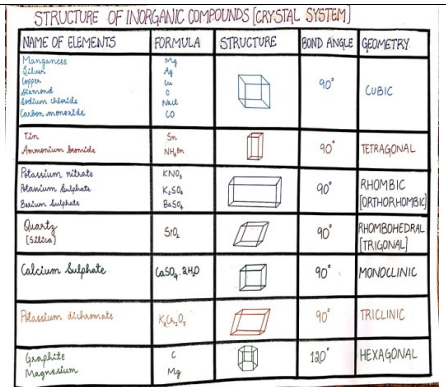
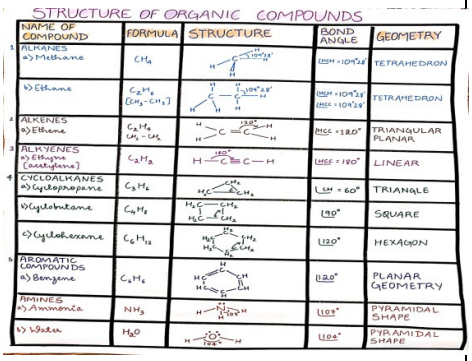
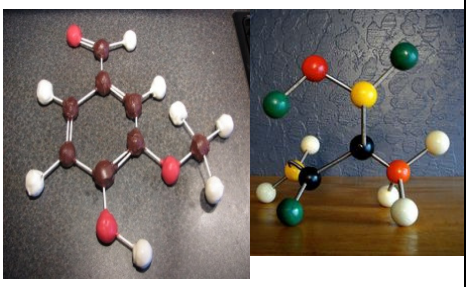
Duplicate molecular structure

Predict geometry of molecules.

Relate the concept of Geometry to Molecular Geometry.

Design the Molecules by using Beads and Sticks.

5E Steps	Content with teacher activities framed to facilitate the students learning	Students activities in constructing the knowledge	Mathematical lab component
Engage	Teacher shows the flashcards of the molecule represented through molecular geometry. **(Observation method)**	Curiously observe the flash cards	**Flash cards** 
Explore	Teacher instructs the students to observe the geometry behind the molecules and ask following questions. 1) What is molecular geometry? 2) What does it determine? **(Observes all students whether they are engaged or not)**	Interact in a positive manner and try to give the answers for all the questions and build the concept of molecular geometry.	**Chart of molecules** 

Explain	Teacher displays the chart containing the name of molecules with bond angles, shapes and geometry (Collaborative method) Motivate students to relate geometry of angles to bond angles. (Observation method)	Observe the shapes, bond angles, geometry of molecules and name the geometry of molecules according to their shapes Uses previous observations to relate the concepts.	 
Elaborate	Teacher provides sticks and beads to the students and facilitates them to arrange those according to the molecular arrangements by looking into the chart. **(Laboratory method)**	Students experience science in varied, interesting and enjoyable ways	

Evaluate	Sketch the following Molecules with their bond angles 1. Methane 2. Water 3. Carbon dioxide	Assess their own progress by comparing their current understanding with their prior knowledge;	

- **Pilot Study**

This phase included the development of the Programme. The Package validated on comprehensibility of the content and activities, difficulty level, time factor, suitability for the given age group and ability level, extent of facilitation for achieving specified instructional objectives. The problems faced by small group of samples were observed by the investigator holding had discussion with them, subsequently and on the basis of the feedback, the Package was finalized with suitable modifications.

Preliminary administration was made on small groups of 35 students of Mary Immaculate girls High School for about 3months, which were not included in the sample. The problems faced by small group of samples were observed by the investigator, holding discussion with them subsequently and on the basis of the feedback, the Package was refined with suitable modifications. During the process opinions and observations of subject teachers and students were collected and accordingly required modification was done by considering their suggestion. Little modifications of lesson Plan, Improvisation of Teaching learning material was done to suit the Contents for class10.

Based on the experience and discussions with the subject experts, some modifications were made in the package to meet the criteria and package finalized for its execution. The Package implemented over a span of 3 months in about 60 periods of 40 minutes each from Monday to Friday of the week.

- **Establishing Validity and reliability**

Eminent experts' opinions were taken on Relevance of Content to Secondary School Students, Clarity of content without Ambiguity, Interdisciplinary approach between Mathematics and Chemistry is properly established.Based on their suggestions, suitable refinement was made in the package. The package was validated by the experts by evaluating the questionnaire. The evaluation questionnaire assessed the suitability of Format, content, organization, and language structure of the Teaching

Chemistry through Mathematics Lab Package and suitability of techniques for enhancing teaching and learning process by using package. It is based on following things,

- Content in this package is relevant to Secondary School Students
- Contents are clear without Ambiguity
- Interdisciplinary approach between Mathematics and Chemistry is properly established.
- Scope of using Maths lab components in teaching Chemistry
- Construction of Lesson plan based on Constructivism Theory.
- Overall Package.

Reliability

Each item of the evaluation questionnaire was rated on 5-point Scale consisting of the following points

- ❖ Strongly agree - Score 5
- ❖ Agree - Score 4
- ❖ Undecided - Score 3
- ❖ Disagree - Score 2
- ❖ Strongly Disagree - Score 1

	Contents in this package is relevant to Secondary School Students	Contents are clear without Ambiguity	Interdisciplinary approach between Mathematics and Chemistry is properly established.	Scope of using maths lab components in teaching Chemistry	Construction of Lesson plan based on Constructivism Theory	Overall Package (Mean)
Expert 1	5	4	5	5	5	5
Expert 2	4	4	5	4	4	5
Expert 3	5	4	5	4	4	5
Expert 4	5	4	4	5	4	5
Expert 5	5	5	4	4	5	5
Expert 6	5	5	4	4	4	4
Expert 7	5	5	4	5	4	4
Expert 8	5	5	5	4	4	4
Expert 9	5	4	4	4	4	5
Expert 10	5	4	5	4	4	5
Average	98%	88%	90%	86%	84%	94%

➢ Rational of the Package

- ❖ This package is suitable for Secondary School students.
- ❖ All the concepts of Chemistry cannot be taught by this method.
- ❖ This package establishes interrelation between Chemistry and Mathematics, to understand Chemistry it is very essential to have the knowledge of mathematics.
- ❖ Establishment of mathematics lab is very essential in all Schools.

➢ **Teaching Methods used:** Laboratory method, Demonstration method, Observation method.

➢ **Teaching and Learning Materials used:** Mathematical Lab Components : Weights, Simple Balance, Objects used to find out masses, Algebraic tiles. Video of Balancing Chemical equation, Chart of chemical equations, Chart Showing the different Geometrical shapes, Geometrical Shapes, Solid Geometrical Shapes, 3D models, Protractor, Scale, Flash cards, Chart of molecules, Chart showing the representation of ratio in words, percentage protractor, Video clip, Formula chart Flower board containing mathematical operations, BODMAS model, Graph chart, Fraction tiles, Charts and Videos.

➢ Conclusion and suggestions

Constructivism supports student directed learning where teachers are only facilitators. Student autonomy and initiative are accepted and encouraged in Constructivist Approach. Students are able to clearly organize the principles they have learned and carry the new knowledge to real life. Students are not always confined to a classroom. Constructivist Approach promotes social and communication skills by creating a classroom environment that encourages group work and collaborative learning. Constructivist educators believe that all knowledge is constructed on the basis of pre-existing knowledge of learners. This construction of individual's subjective reality should be of interest to practitioners and researchers in education and in particular to the teachers of science. Today is the age of knowledge explosion. Constructivist Approach opens up new avenues for knowledge construction as well as challenges for the teacher trying to implement it. Constructivism can transform thinking and practice beyond traditional models and boundaries of schools and educational systems. Establishment of mathematics lab is essential for all Secondary Schools.

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