ACTIVITY 15

Exploring Molecular Symmetry with Platonic Solids (GeoGebra)

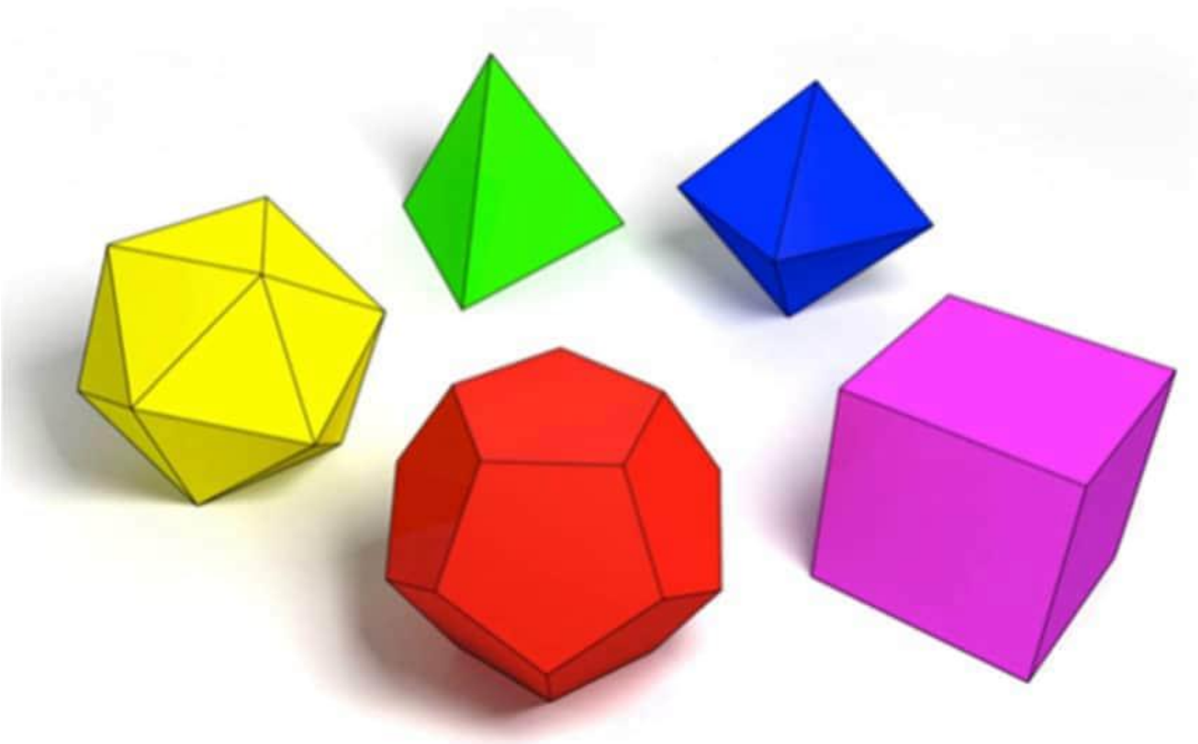
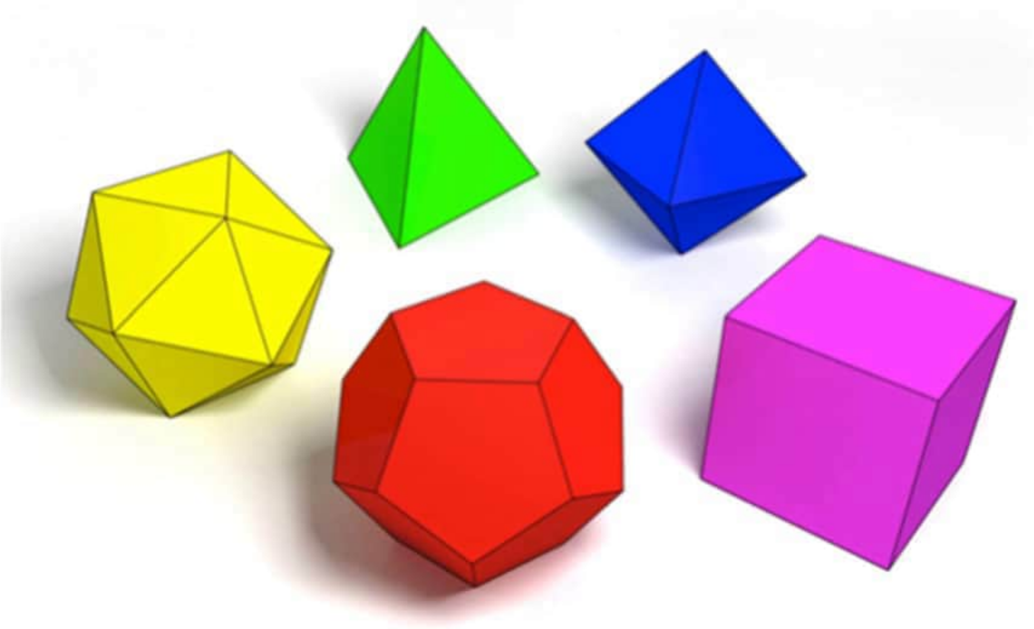


Illustration from the activity

Exploring Molecular Symmetry with Platonic Solids, GeoGebra and 3D Printing

RELATED SUBJECTS	GRADE RECOMMENDATIONS	TOTAL ACTIVITY TIME	LEARNING OBJECTIVES DURING THE LESSON SUBJECT-SPECIFIC COMPETENCIES	LEARNING OBJECTIVES AFTER THE LESSON
Mathematics, Science, Technology, Arts	Grades 10-12 (Ages 15-17)	5 lessons (45 mins x 5)	- Understand symmetry concepts and apply them to Platonic solids and molecular geometry. - Gain proficiency in GeoGebra for digital 3D modeling. - Represent scientific concepts creatively through artistic activities.	- Apply symmetry understanding to predict molecular properties. - Continue developing skills in digital modeling and artistic representation.

TOPIC & PURPOSE:



This interdisciplinary unit connects mathematics, science, technology, and arts by exploring molecular symmetry using Platonic solids. Students engage in hands-on activities with GeoGebra and 3D printing to visually and creatively enhance their understanding.

ACTIVITY PRE-REQUISITES:

- Basic geometric understanding of polyhedra and symmetry.
- Introductory knowledge of GeoGebra.

3D Modelling and 3D Printing Integration

3D MODELING TOOLS AND SOFTWARE:	GeoGebra software.
3D PRINTING PROCESS:	Students design 3D structures using GeoGebra, export their models as STL files, and print using 3D printers.
LEARNING OBJECTIVES RELATED TO 3D MODELING AND PRINTING:	- Skills to accurately create 3D digital models. - Practical understanding of 3D printing technology and processes.

STEAM Elements

STEAM SUBJECTS	SCIENCE	TECHNOLOGY	ENGINEERING	ARTS	MATHEMATICS
SHORT INTRODUCTION TO RELATED SUBJECT ELEMENTS	Analysis and understanding of molecular symmetry and geometry.	Utilizing GeoGebra for digital 3D modeling.	Designing and constructing accurate 3D models.	Creating artistic representations of scientific concepts and symmetry.	Exploration of spatial geometry, symmetry, and Platonic solids.

Syllabus

LESSONS	SUBJECTS	TOPIC OF THE UNIT	LEARNING OBJECTIVES DURING THE LESSON: SUBJECT-SPECIFIC COMPETENCIES	LEARNING OBJECTIVES AFTER THE LESSON: STEAM COMPETENCIES
1	Math, Science, Tech	Introduction to Symmetry and Platonic Solids	Identify symmetry properties, define Platonic solids.	Recognize symmetry's role in real-world science applications.
2	Math, Tech	GeoGebra for Modeling Platonic Solids	Create digital models using GeoGebra software.	Develop digital skills transferable to other software applications.
3	Science, Math, Tech	Exploring Molecular Geometry with GeoGebra	Visualize molecular geometry digitally.	Apply visualization techniques to scientific inquiry.
4	Arts, Tech	Artistic Representation of Molecular Symmetry	Represent molecular symmetry artistically.	Enhance creativity and integrate art with science and technology.
5	Engineering, Tech, Math	3D Printing Models of Molecular Structures	Design accurate digital models for printing.	Acquire hands-on engineering skills with 3D printing technology.

Instructional Plan by Lesson

(Copy this section as many times as needed for each lesson)

TIME PLAN	TEACHING & LEARNING ACTIVITIES	MATERIALS (SOFTWARE, HARDWARE)	LEARNING OBJECTIVES
INTRODUCTION (5 MINUTES)	Welcome students and introduce the topic through a short visual presentation. • Pose an opening question: "Where do we see symmetry in nature or design?" • Show images of snowflakes, honeycombs, and architecture (e.g., the Parthenon). | - Projector or smartboard • PowerPoint with visual prompts • Real-world symmetry photo slides | - Identify symmetry in nature and structures • Spark curiosity about geometric patterns	• PowerPoint • Projector or smartboard	Spark curiosity, refresh knowledge

LEARNING ACTIVITIES (10 MINUTES)	Define **symmetry types**: line symmetry, rotational symmetry. • Introduce **Platonic solids**: tetrahedron, cube, octahedron, dodecahedron, icosahedron. • Explore how symmetry is inherent in each Platonic solid. • Show animated 3D renderings and discuss face, edge, and vertex properties. • Quick student sketching activity: draw 2D representations of Platonic solids. | • - Define and describe Platonic solids • Identify symmetry types in geometric figures	• - Geogebra 3D or other 3D geometry visualizer • Handouts with solid diagrams • Whiteboard or drawing tablets |	Build foundational geometric vocabulary |
3D MODELLING ACTIVITIES (10 MINUTES)	Guide students in designing a basic Platonic solid in a 3D modeling tool (e.g., Tinkercad).	• Tinkercad (free online 3D modeling tool) • Teacher example model |	• Use symmetry knowledge in spatial modeling

	• Each student chooses one solid to build digitally. • Highlight symmetry in their models—discuss how the model is balanced or regular. | - Laptops or tablets		• Develop digital fabrication skills • Apply understanding of geometry to create digital 3D models
3D PRINTING ACTIVITIES (10 MINUTES)	Demonstrate how to prepare the digital model for 3D printing (STL file export, slicer settings). • Start printing a few small models (if time allows). • Explain how 3D printing uses geometry and symmetry for precision manufacturing. • Discuss real-world applications: engineering, medical implants, architecture. | - 3D printer (e.g., Prusa, Creality)	- Slicing software (e.g., Cura) - Sample 3D printed solids - Connect geometry to real-world design and manufacturing	• Understand basic 3D printing workflow • Recognize interdisciplinary uses of geometry and symmetry |
WRAP-UP & EVALUATION (X MINUTES)	Group discussion: How did symmetry help in designing the solids?		

	• Exit Ticket: Each student answers 2 questions: 1. Name one real-world object that resembles a Platonic solid. 2. How does symmetry improve design or function in science/tech? • Optional: Quick Kahoot or quiz on symmetry and solids. | - Exit ticket handout or online form • (Optional) Kahoot app for quiz | - Reflect on the role of symmetry in 3D design • Recognize cross-disciplinary (STEAM) connections • Solidify conceptual understanding through reflection and assessment |		

TIME PLAN	TEACHING & LEARNING ACTIVITIES	MATERIALS (SOFTWARE, HARDWARE)	LEARNING OBJECTIVES
INTRODUCTION (5 MINUTES)	Recap from Lesson 1: Briefly review what Platonic solids are and their symmetry properties. • Ask: "Why is it important to model solids digitally in STEM fields?" • Introduce GeoGebra 3D Calculator as a powerful modeling tool. • Show example of a completed Platonic solid in GeoGebra. | - Projector or smartboard • GeoGebra 3D demo file • Recap slides (optional) | - Connect previous knowledge of Platonic solids to digital modeling	• Projector or smartboard • GeoGebra 3D Calculator	• Understand relevance of digital tools in STEM careers
LEARNING ACTIVITIES (10 MINUTES)	- Walk students through the **GeoGebra 3D interface**: axes, tools, object tree, input bar. • Demonstrate step-by-step how to construct a	• - Computers or tablets • GeoGebra 3D Calculator (online or desktop version)	• Create and manipulate geometric structures Reinforce understanding of faces, edges, and vertices through modeling |

	tetrahedron using point and polygon tools. • Emphasize how GeoGebra shows symmetry in real-time. • Students replicate the process on their own screens.		
3D MODELLING ACTIVITIES (15 MINUTES)	- Students choose a Platonic solid (not tetrahedron) and model it using GeoGebra. • Encourage experimentation with transformations (rotation, zoom, scaling). • Circulate to assist with challenges in aligning faces or creating regular polygons. • Peer support activity: students review a partner's model for accuracy. | -	• GeoGebra (each student or pair)	• Practice precision and spatial reasoning • Collaborate to evaluate and refine 3D constructions • Apply geometry knowledge through software modeling
3D PRINTING ACTIVITIES (5 MINUTES)	Brief overview: exporting GeoGebra 3D models to STL format for 3D printing.	• Example STL files from GeoGebra	• - Understand how digital geometry models can be used in

	• Teacher demonstrates STL export from GeoGebra (if supported) or discusses how files can be transferred to other 3D design platforms. • Emphasize the **interoperability** of digital skills across platforms (e.g., GeoGebra → Tinkercad → Cura). | - Screen recording or live demo of exporting process	• 3D printer optional (for showing use case)	real-world design and fabrication • Learn basics of file export and interoperability between software platforms
WRAP-UP & EVALUATION (10 MINUTES)	Group reflection: "What was easy or challenging about building solids digitally?" • Students present their model to a small group or class. • Exit Task: 1. Screenshot of their model 2. Written description: name of solid, number of	Screenshots of student work	Practice digital communication of technical ideas Build confidence in using math and tech tools collaboratively

	faces/edges/vertices, symmetry type		

TIME PLAN	TEACHING & LEARNING ACTIVITIES	MATERIALS (SOFTWARE, HARDWARE)	LEARNING OBJECTIVES
INTRODUCTION (5 MINUTES)	Begin with a guiding question: "Why do molecules have different shapes, and how does shape affect function?" • Show real-life molecule models: H_2O, CH_4, CO_2, NH_3. • Connect molecular shapes to geometry (bond angles, symmetry, 3D structure). • Introduce **VSEPR Theory** as the scientific basis for predicting molecular shapes.	- Projector or smartboard • Visuals of simple molecules	Ball-and-stick models (optional)	□ - Understand the concept of molecular geometry □ Recognize the role of geometry in molecular function □ Engage curiosity around visualizing molecules in 3D
LEARNING ACTIVITIES (10 MINUTES)	- Explain the **VSEPR model**: electron pairs repel and define molecular shape.	Whiteboard or online Jamboard for group matching	□ - Classify molecules by shape and bond angles

	• Introduce key shapes: linear, trigonal planar, tetrahedral, trigonal pyramidal, bent. • Show angle differences (e.g., 180°, 120°, 109.5°). • Use diagrams and angle overlays to connect to geometric reasoning. • Group brainstorm: Match common molecules to VSEPR shapes.		Use geometry to explain 3D structure Build connections between molecular and mathematical reasoning
3D MODELLING ACTIVITIES (15 MINUTES)	- Demonstrate how to model molecules using **GeoGebra 3D Calculator**: • Place atoms using points • Use segments or vectors for bonds • Set angles to match VSEPR geometries • Students choose a molecule (e.g., CH_4, H_2O, CO_2) and recreate it in GeoGebra.	- Computers or tablets GeoGebra 3D Angle and segment tools in GeoGebra	- Visualize abstract molecular geometry in 3D Apply geometry tools to model real scientific structures Reinforce concepts through digital construction and manipulation

	• Emphasize symmetry and accurate angle construction. • Optional: use color coding (e.g., red = oxygen, white = hydrogen).		
3D PRINTING ACTIVITIES (5 MINUTES)	- Teacher demonstrates exporting a molecule model to STL format (if applicable). • Explain how 3D printing is used in science for prototyping and visualizing molecular structures. • Showcase a pre-printed molecular model if available. • Discuss how these models aid in chemistry, pharmacology, and materials science. | - STL-ready example model	□ 3D printer or printed model (optional) □ Demonstration video (if printing not possible)	□ - Understand the intersection of science and 3D technology □ Recognize visualization as a tool in scientific research □ Connect abstract models to tangible scientific applications
WRAP-UP & EVALUATION (10 MINUTES)	- Peer review: students present their molecular models in small groups.	□ - Exit reflection prompt (printed or digital)	□ - Reflect on learning through self-assessment and peer discussion

	• Reflective questions (can be written or discussed): 1. What surprised you about your molecule's shape? 2. How did geometry help you understand it better? • Exit Task: Submit screenshot of model + short reflection. • Optional quiz or Kahoot on molecule shapes and bond angles.	Screenshot submission platform (Google Classroom, LMS) Kahoot (optional)	Reinforce understanding of molecular geometry Apply digital modeling to support scientific thinking **Subject-Specific Competencies (During the Lesson)** • Understand VSEPR theory and apply it to real molecules. • Construct and visualize molecular structures using geometric reasoning. • Build models that accurately reflect scientific data. **STEAM Competencies (After the Lesson)** • Apply visualization techniques in scientific inquiry. • Use digital tools to represent and analyze scientific structures.

			• Strengthen cross-disciplinary problem-solving through 3D modeling and technology

TIME PLAN	TEACHING & LEARNING ACTIVITIES	MATERIALS (SOFTWARE, HARDWARE)	LEARNING OBJECTIVES
INTRODUCTION (5 MINUTES)	- Begin with a thought-provoking question: "What do molecules and art have in common?" • Show examples of **molecular symmetry in visual form**: ○ Benzene rings, DNA double helix, snowflake symmetry • Briefly explain **types of symmetry**: radial, reflective, rotational—relating them to molecular structures. • Set the goal: Create a digital or hand-drawn art	- Projector or smartboard Slideshow of molecular structures and symmetry in nature/art Physical models or molecular structure images	- Recognize symmetry in molecular structures Understand the artistic potential of scientific forms Stimulate interest in combining art and science

	piece that highlights molecular symmetry.		
LEARNING ACTIVITIES (X MINUTES)	- Introduce **molecular symmetry groups** with simple examples (e.g., CH_4—tetrahedral, benzene—hexagonal). • Explore how molecular symmetry can be represented artistically (mandalas, tessellations, digital patterns). • Show examples of **scientific illustrations** and **abstract molecular art**. Group brainstorm: What artistic styles (geometric, abstract, mandala) could represent different molecules?	- Printouts or digital slides of molecule diagrams and symmetry Chart of symmetry types in common molecules Examples of molecular-inspired art	- Analyze the symmetry found in molecules Develop an idea for artistically expressing scientific content Prepare to blend visual arts with scientific structure
3D MODELLING ACTIVITIES (15 MINUTES)	- Students choose a molecule (e.g., methane, benzene, water) and design a **symmetry-based artwork** using digital tools or by hand: • Option A: Use **digital design tools** (e.g., Canva,	- Tablets or laptops Canva, GeoGebra Art Tools, or drawing software Paper, colored pencils/markers (for hand-drawing option)	- Represent molecular symmetry through visual art Use digital tools to transform scientific concepts into artistic designs

	Adobe Illustrator, or GeoGebra Art Tools) to create geometric art. • Option B: Hand-drawn piece with symmetry lines, patterns, and molecular form. • Emphasize the artistic representation of **rotational or reflective symmetry**. • Allow creative freedom while ensuring accurate reference to molecular structure. |		Foster creativity through structured, science-informed expression
3D PRINTING ACTIVITIES (5 MINUTES)	- For digital designs: • Export as PNG/SVG and prepare for display or digital gallery. • Discuss optional extension: converting geometric art into 3D printable form (e.g., using Tinkercad or Blender). • For hand-drawn works: Scan and digitize for sharing or printing.	Scanner or camera (for physical artwork) File export tools Shared Google Drive or class website (Optional) 3D printer or design software	- Understand how art can be shared and reproduced using tech Learn to prepare digital files for visualization and display Explore future potential of combining art, tech, and fabrication

	• Students may start uploading work to a **shared online gallery or class portfolio** •		
WRAP-UP & EVALUATION (10 MINUTES)	- Gallery Walk: Students display work digitally or on paper and walk around to observe others' art. • Reflection questions: 1. "How did symmetry influence your artistic choices?" 2. "How did the molecule's structure guide your design?" • Peer-to-peer feedback using sticky notes or digital comments. • Collect or submit artwork and short artist's statement.	- Printed or digital reflection prompts Display board or shared digital space Sticky notes or online comment board (Padlet, Google Jamboard)	- Reflect on scientific and artistic processes Appreciate peers' creative interpretations of molecular symmetry Practice scientific communication through artistic expression **Subject-Specific Competencies (During the Lesson)** • Identify and interpret molecular symmetry in artistic contexts. • Use scientific structure as inspiration for visual expression. • Understand how symmetry appears in both art and chemistry. **STEAM Competencies (After the Lesson)**

			• Integrate visual arts with science and technology creatively. • Communicate scientific ideas through artistic media. • Apply design-thinking in transforming molecular forms into artistic visuals.

TIME PLAN	TEACHING & LEARNING ACTIVITIES	MATERIALS (SOFTWARE, HARDWARE)	LEARNING OBJECTIVES
INTRODUCTION (5 MINUTES)	- Pose a real-world scenario: “Imagine you're designing a 3D molecular model for a biotech company. What makes a model effective?” • Review prior concepts: Platonic solids, molecular symmetry, digital modeling. • Introduce the goal: **Design a 3D model of a molecule** that is both **scientifically accurate** and **print-ready**.	☐ - 3D printed sample models ☐ Projector or smartboard ☐ Recap chart or poster of symmetry types and molecule examples	☐ - Connect prior knowledge to an engineering task ☐ Understand real-world applications of molecular modeling ☐ Set clear design goals for the project

	• Show examples of professional molecular models used in labs and education.		
LEARNING ACTIVITIES (10 MINUTES)	- Review basic molecular geometry and **bond angle approximations** using prior examples (e.g., methane = tetrahedral). • Introduce **CAD-based design criteria** for printability: o Correct scale and proportions o Bond placement (equal length, correct angles) o Structural stability for printing • Explain **safety and best practices** for 3D modeling and printing.	Whiteboard or drawing tablet for angle/bond diagrams	- Translate molecular geometry into measurable design choices Learn engineering design considerations for printing Prepare to create print-ready files

3D MODELLING ACTIVITIES (15 MINUTES)	- Students choose a molecule (e.g., CH_4, NH_3, CO_2, C_6H_6) and model it using a CAD tool: • Recommended: **Tinkercad**, **Blender**, or **Fusion 360 for Education** • Guide students to: ○ Place atoms (spheres) and bonds (cylinders or rods) ○ Align angles to match VSEPR predictions ○ Group/merge components into a single object ○ Check model for overhangs and printability	- Computers or laptops CAD software: Tinkercad, Fusion 360, or Blender Pre-designed tutorial files (optional) Bond length and angle reference chart	- Apply math and geometry in digital modeling Use spatial reasoning to construct scientifically accurate forms Prepare a CAD model for 3D printing using engineering standards
3D PRINTING ACTIVITIES (10 MINUTES)	- Demonstrate how to export STL files and import them into **slicer software** (e.g., Cura, PrusaSlicer): • Adjust print settings (layer height, infill, supports if needed)	- Slicing software: Cura, PrusaSlicer 3D printer(s) (FDM recommended) STL files from student work	- Learn the full digital-to-physical workflow Understand engineering principles in fabrication Gain practical exposure to additive manufacturing

	• Preview the slicing path • Begin printing selected student models (small-scale or selected few) • Discuss **printer mechanics and technology**: FDM vs. SLA, layer-by-layer deposition, troubleshooting common errors	Live print preview on screen	
WRAP-UP & EVALUATION (5 MINUTES)	- Gallery display: students place their printed or digital models for class viewing. • Reflection prompt (written or oral): 1. "What did you learn about engineering through this process?" 2. "How did accuracy and design choices impact your final model?" • Optional: Class vote on "Most Accurate," "Most	Certificates or stickers (optional) for STEAM Awards	- Reflect on the design and printing process Assess accuracy, functionality, and aesthetics of models Celebrate STEAM integration and achievement **Subject-Specific Competencies (During the Lesson)** • Design and model molecular structures using CAD tools.

	Artistic," and "Most Complex" model (STEAM Awards). • Collect final CAD files and reflection responses.		• Apply geometric knowledge to real-world fabrication. • Understand the steps from digital design to 3D printing. **STEAM Competencies (After the Lesson)** • Acquire hands-on engineering skills through 3D printing. • Integrate technology, math, and science to solve design challenges. • Engage in iterative thinking, refining designs for practical application.

Evaluation Plan by Lesson

LESSON	EVALUATION CRITERIA	EVALUATION METHOD	3D MODELING AND PRINTING ASSESSMENT:

1	Does the student demonstrate clear understanding of symmetry concepts and molecular geometry?	Creating a detailed concept map and digital models in GeoGebra.	*Presence of clear symmetry in the model (line or rotational).*
2	Did the student accurately model molecular geometry digitally?	Observation and peer-review of digital GeoGebra models.	*Solid is positioned and proportioned accurately in 3D space.*
3	Can the student clearly present their models and explain the underlying symmetry concepts?	Peer-review presentations and teacher evaluation.	*Accurate positioning of atoms and bonds in 3D space (reflects scientific understanding).*
4	Can the student independently design and print a structurally accurate 3D model?	Creating independent projects using GeoGebra to design and print 3D models.	*Neatness, detail, and digital or hand-rendered quality.*
5	Did students effectively collaborate during group activities and model creation?	Self-assessment, group observation, and reflective discussions.	*Printed object has minimal defects, maintains structure and clarity.*

Additional Resources

NOTES:

ACTIVITY SHEETS TO BE LINKED:

EVALUATION MATERIALS TO BE LINKED:

REFERENCES / SUPPORTING MATERIALS TO BE LINKED:

- www.geogebra.org
- https://espanol.libretexts.org/Quimica/Qu%C3%ADmica_General/Libro%3A_Chem1_(Inferior)/09%3A_Uni%C3%B3n_qu%C3%ADmica_y_estructura_molecular/9.05%3A_Geometr%C3%ADa_Molecular
- https://www.cuemath.com/geometry/platonic-solids/

- https://www.dailymotion.com/video/xpgi0v

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3D STEAM

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