



## Design Your Own Geometrical Chess Set

Laura Engelscharmüllner & Daniel Deixler

| RELATED SUBJECTS                             | GRADE<br>RECOMMENDATIONS | TOTAL ACTIVITY<br>TIME            | LEARNING OBJECTIVES<br>DURING THE LESSON<br>SUBJECT-SPECIFIC<br>COMPETENCIES  | LEARNING OBJECTIVES<br>AFTER THE LESSON  |
|--|--------------------------|-----------------------------------|---|--|
| Mathematics, Handicraft,<br>Digital Literacy | Grades 7-10 (Ages 13-16) | 270 minutes (3<br>double lessons) | <ul> <li>Understand basic geometry<br/>of chess figures.</li> <li>Use digital modeling software<br/>effectively (Tinkercad).</li> <li>Develop crafting skills by<br/>creating a physical<br/>chessboard.</li> </ul> | <ul> <li>Enhanced spatial<br/>reasoning, logical thinking,<br/>and creativity.</li> <li>Practical experience with<br/>digital fabrication and 3D<br/>printing technology.</li> </ul> |





















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Students design and 3D print custom chess sets, simultaneously crafting chessboards to practically engage with geometry, technology, and handicraft skills.

- Basic geometry (shapes, volumes, spatial reasoning).
- Introductory skills in digital technology and software usage.

## 3D Modelling and 3D Printing Integration

| 3D MODELING TOOLS<br>AND SOFTWARE:                                | Tinkercad, Craftware Pro   |
|---|--|
| 3D PRINTING PROCESS:  | Students will design chess figures in Tinkercad, export as STL files, prepare in Craftware Pro, and print using a 3D<br>printer. |
| LEARNING OBJECTIVES<br>RELATED TO 3D<br>MODELING AND<br>PRINTING: | - Accurate digital modeling.<br>- Practical experience in 3D printing preparation and execution.                                 |





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## **STEAM Elements**

| STEAM<br>SUBJECTS   | SCIENCE  | TECHNOLOGY   | ENGINEERING  | ARTS  | MATHEMATICS  |
|---|--|--|--|---|--|
| SHORT<br>INTRODUCTIO<br>N TO RELATED<br>SUBJECT<br>ELEMENTS | Understanding<br>material<br>properties and<br>structural stability<br>of printed objects. | Digital modeling and<br>using 3D printing<br>software. | Designing, preparing,<br>and executing 3D<br>prints. | Aesthetic design of<br>chess figures and<br>chessboard. | Geometric shapes, spatial reasoning, and measurements. |















## Syllabus

| LESS<br>ONS | SUBJECTS                         | TOPIC OF THE UNIT  | LEARNING OBJECTIVES DURING<br>THE LESSON: SUBJECT-SPECIFIC<br>COMPETENCIES   | LEARNING OBJECTIVES<br>AFTER THE LESSON: STEAM<br>COMPETENCIES   |
|-------------|----------------------------------|--|--|--|
| 1           | Mathematics, Digital<br>Literacy | Introduction to Chess<br>Geometry and Figures  | <ul> <li>Exploring the link between chess pieces and geometric forms</li> <li>Introduction to 3D modeling basics</li> <li>- Understand geometric properties (e.g., symmetry, shapes, volumes) of chess figures</li> <li>Apply knowledge of 2D and 3D geometry to conceptualize a design</li> <li>Gain basic skills in navigating and using Tinkercad for modeling</li> </ul> | <ul> <li>Develop spatial reasoning<br/>through geometry-driven design</li> <li>Strengthen logical thinking<br/>through the rules and structure of<br/>chess</li> <li>Build foundational digital skills<br/>applicable across design and<br/>tech platforms</li> </ul>    |
| 2           | Mathematics,<br>Technology       | <ul> <li>Digital Modeling and 3D</li> <li>Printing Preparation         <ul> <li>Designing digital chess figures in Tinkercad</li> <li>Preparing files for 3D printing with slicing software</li> </ul> </li> </ul> | <ul> <li>Create accurate 3D chess<br/>models using geometric tools and<br/>modeling techniques</li> <li>Apply mathematical concepts<br/>(proportion, symmetry,<br/>transformation) in modeling</li> <li>Learn the basics of 3D slicing<br/>software and export processes</li> </ul>  | <ul> <li>Acquire technical skills in 3D design and printing workflow</li> <li>Experience the iterative design process, adjusting models for functionality and printability</li> <li>Understand the link between mathematical design and engineering execution</li> </ul> |





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| 3 | Handicraft, Arts | <ul> <li>Crafting the Chessboard<br/>and Final Presentation <ul> <li>Building and<br/>decorating a<br/>physical<br/>chessboard</li> <li>Reflecting on the<br/>full project</li> <li>Chess gameplay<br/>using printed<br/>pieces</li> </ul> </li> </ul> | • | <ul> <li>Develop manual crafting and<br/>measurement skills through<br/>construction of a chessboard<br/>Practice artistic expression<br/>through painting and customizing<br/>designs</li> <li>Engage in reflective and strategic<br/>thinking through chess gameplay<br/>and discussion</li> </ul> | <ul> <li>Integrate creative and<br/>engineering practices to present<br/>a complete STEAM project</li> <li>Apply learned skills in<br/>geometry, design, and fabrication<br/>in a hands-on, collaborative<br/>setting</li> <li>Develop presentation and<br/>peer feedback skills through<br/>class exhibition and gameplay<br/>experience</li> </ul> |
|---|------------------|--|---|--|--|















## Instructional Plan by Lesson

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

| TIME PLAN                 | TEACHING & LEARNING<br>ACTIVITIES    | MATERIALS (software,<br>hardware) | LEARNING OBJECTIVES        |
|---------------------------|--------------------------------------|-----------------------------------|----------------------------|
| INTRODUCTION (10 MINUTES) | - Present the overall project        | - Presentation slides             | - Understand the           |
|                           | scope: designing a custom chess      | Physical chess set or             | connection between chess   |
|                           | set                                  | images                            | and geometry               |
|                           | Brief history of chess and the       |                                   | Recognize geometric        |
|                           | geometry behind chess figures        |                                   | features in existing chess |
|                           | Discuss how shapes represent         |                                   | pieces                     |
|                           | function (e.g., bishop's cut, rook's |                                   |                            |
|                           | tower)                               |                                   |                            |
|                           |                                      |                                   |                            |
| LEARNING ACTIVITIES (25   | □ Geometry activity: identify basic  | Rulers, geometry templates        | Analyze the composition    |
| minutes)                  | 3D shapes in chess figures           |                                   | of geometric objects       |
|                           | Group task: sketch one chess         |                                   | Apply geometric reasoning  |
|                           | piece using only geometric shapes    |                                   | in real-world design tasks |
|                           | Class discussion: what               |                                   |                            |
|                           | challenges might arise when          |                                   |                            |
|                           | modeling these pieces digitally?     |                                   |                            |
|                           | Introduction to Tipkersed:           |                                   |                            |
| 3D MODELLING ACTIVITIES   | Introduction to Inkercad:            | Computers     Tinkereed (enline)  | - Use basic CAD tools to   |
| (35 minutes)              |                                      | $\Box$ Theorem tutorial file      |                            |
|                           | datan by stop                        |                                   |                            |
|                           | siep-by-siep                         |                                   | SD space                   |















|  | <ul> <li>Students begin rough modeling<br/>of a second piece (their choice)</li> </ul>   |  |   |
|--|--|--|---|
| 3D PRINTING ACTIVITIES (10<br>minutes) | <ul> <li>Teacher shows STL file<br/>export process</li> <li>Live demonstration of importing<br/>file into slicing software (Craftware<br/>or Cura)</li> <li>Show preview of a print job</li> </ul>                               | <ul> <li>Sample STL files</li> <li>3D printer or slicing<br/>preview on projector</li> <li>Craftware or Cura<br/>software</li> </ul> | - Understand the pipeline<br>from design to print<br>Learn basic file handling and<br>slicing concepts  |
| WRAP-UP & EVALUATION (10<br>MINUTES)   | <ul> <li>Recap what shapes belong to<br/>which piece</li> <li>Q&amp;A: What worked in Tinkercad?<br/>What was confusing?</li> <li>Exit ticket: name 3 geometric<br/>solids and one use in your chess<br/>piece design</li> </ul> | Discussion prompts on<br>board   | <ul> <li>Reflect on first<br/>experiences with digital<br/>modeling</li> <li>Solidify geometry<br/>vocabulary and<br/>Tinkercad basics  </li> </ul> |

| TIME PLAN                | TEACHING & LEARNING<br>ACTIVITIES | MATERIALS (SOFTWARE,<br>HARDWARE) | LEARNING OBJECTIVES  |
|--------------------------|-----------------------------------|-----------------------------------|--|
| INTRODUCTION (5 MINUTES) | - Review last lesson's models     | Student models                    | <ul> <li>Set clear goal for<br/>modeling completion</li> </ul> |















|   | Introduce today's goal: design,<br>finalize, and prepare full chess<br>piece set for printing   | <ul> <li>Tinkercad and slicing<br/>software screenshots</li> </ul>  | <ul> <li>Understand full design-to-<br/>print workflow</li> </ul>   |
|---|---|---|---|
| LEARNING ACTIVITIES (15<br>MINUTES)     | <ul> <li>Peer review: Students<br/>exchange models and give<br/>feedback (accuracy, creativity)</li> <li>Teacher mini-demo: How to<br/>check if a model is "watertight"<br/>and printable</li> <li>Discussion: Scaling, symmetry,<br/>and piece proportion</li> </ul> | <ul> <li>Teacher sample models<br/>(correct/incorrect)</li> </ul>   | <ul> <li>Evaluate 3D designs with<br/>an engineering mindset</li> <li>Use peer feedback<br/>constructively</li> </ul> |
| 3D MODELLING ACTIVITIES<br>(45 minutes) | <ul> <li>Students refine existing<br/>models or create new pieces<br/>(goal: complete at least 3–4<br/>distinct pieces)</li> <li>Optional: Advanced modeling<br/>tips (chamfering, group/un-group,<br/>holes)</li> <li>Save STL files for printing</li> </ul>         | <ul> <li>Computers</li> <li>Tinkercad</li> <li>Teacher modeling help<br/>sheet</li> </ul>                         | <ul> <li>Use advanced modeling<br/>techniques</li> <li>Finalize printable designs<br/>using CAD tools</li> </ul>      |
| 3D PRINTING ACTIVITIES (15<br>MINUTES)  | <ul> <li>Students practice slicing their</li> <li>STL files with teacher guidance</li> <li>Adjust orientation, infill,</li> <li>supports</li> <li>Start printing one student piece</li> <li>if time allows</li> </ul>   | <ul> <li>Craftware, Cura, or</li> <li>PrusaSlicer</li> <li>3D printer</li> <li>Sample print queue list</li> </ul> | - Learn slicing software basics<br>Prepare files independently<br>for printing  |















| WRAP-UP & EVALUATION (10<br>minutes) | <ul> <li>Group discussion: What did<br/>you change and why?</li> <li>Submit STL files and peer<br/>feedback forms</li> <li>Reflection prompt: What makes<br/>a model both creative and<br/>functional?</li> </ul> | <ul> <li>Submission folder</li> <li>Printed or digital<br/>reflection sheet</li> </ul> | <ul> <li>- Reflect on modeling<br/>process and peer input</li> <li>Assess readiness for<br/>3D printing</li> </ul> |
|--------------------------------------|---|--|--|

| TIME PLAN                           | TEACHING & LEARNING<br>ACTIVITIES   | MATERIALS (software,<br>hardware)  | LEARNING OBJECTIVES   |
|-------------------------------------|---|--|---|
| INTRODUCTION (10 MINUTES)           | - Present today's challenge:<br>design and decorate the<br>chessboard<br>Show aesthetic examples<br>(minimalist, ornate, geometric<br>styles)                                 | <ul> <li>Sample boards (images or physical)</li> <li>Color palettes and design references  </li> </ul> | <ul> <li>Inspire creative planning and<br/>craftsmanship</li> <li>Link board aesthetics to<br/>game strategy</li> </ul>                     |
| LEARNING ACTIVITIES (40<br>MINUTES) | <ul> <li>Students measure and draw out the chessboard</li> <li>Cut or prepare materials (wood, cardboard, foamboard)</li> <li>Begin painting or decorating squares</li> </ul> | - Rulers, cutters, paint,<br>markers<br>Chessboard templates   | <ul> <li>Apply accurate</li> <li>measurements and precision</li> <li>Practice planning and</li> <li>execution in physical design</li> </ul> |















| 3D MODELLING ACTIVITIES                | -   | -  | -   |
|--|---|--|---|
| (X MINUTES)                            |   |  |   |
| 3D PRINTING ACTIVITIES (20<br>minutes) | <ul> <li>Continue printing chess pieces</li> <li>(rotate through students)</li> <li>Students observe the printing</li> </ul>  | <ul> <li>3D printer</li> <li>Previously sliced files</li> <li>Troubleshooting checklist</li> </ul> | <ul> <li>Gain insight into printing<br/>process and quality control</li> <li>Learn from success or<br/>failure of their models</li> </ul>           |
|  | <ul> <li>Decess and troubleshoot if</li> <li>needed</li> <li>Compare printed pieces to</li> <li>digital models</li> </ul>   |  |   |
| WRAP-UP & EVALUATION (20               | Final chessboard and piece  | Photo station or display   | Reflect on full STEAM   |
| MINUTES)                               | <ul> <li>display</li> <li>Play chess with their own sets (if all pieces ready)</li> <li>Group reflection and feedback: "What was your favorite part of the process?"</li> <li>"What skill did you improve the most?"</li> </ul> | wall <ul> <li>Chess game setup</li> </ul>  | <ul> <li>experience</li> <li>Practice strategic thinking<br/>and presentation skills</li> <li>Celebrate craftsmanship<br/>and creativity</li> </ul> |

## Evaluation Plan by Lesson

| LES<br>SON | EVALUATION CRITERIA | EVAL                           | LUATION METHOD   | 3D MODELING AND PRINTING<br>ASSESSMENT: |                             |                                      |
|------------|---------------------|--------------------------------|--|---|-----------------------------|--------------------------------------|
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| I | Does the student understand how geometric<br>forms relate to chess piece design?<br>Can the student identify and describe key shapes<br>used in 3D modeling?   | <ul> <li>Concept mapping: students draw and label<br/>shapes within chess pieces</li> <li>Observation during sketching and<br/>geometry activities</li> <li>Exit ticket with terminology questions</li> </ul>                          | <ul> <li>Accuracy in identifying basic shapes<br/>(sphere, cone, cylinder) within chess piece<br/>sketches</li> <li>Quality of first Tinkercad model (e.g.,<br/>basic pawn), evaluated using a simple rubric<br/>(shape use, symmetry, completeness)</li> <li>Ability to group and align shapes properly<br/>in the 3D workspace</li> </ul>                               |
|---|--|--|---|
| 2 | Did the student create accurate and functional<br>3D models of multiple chess pieces?<br>Can the student prepare STL files correctly for<br>slicing and printing?  | <ul> <li>Teacher observation during Tinkercad<br/>modeling session</li> <li>Peer review using a checklist<br/>(creativity, symmetry, recognizability)</li> <li>Submission of STL files and reflection<br/>on design changes</li> </ul> | <ul> <li>Use of consistent scale, symmetry, and correct shape combinations</li> <li>Successful export of watertight STL files with proper grouping</li> <li>Completion of slicing in software with correct print orientation, infill, and support settings</li> <li>Initial test prints evaluated on form accuracy and structural stability</li> </ul>                    |
| 3 | Is the student able to present their chess set with<br>confidence, showing both craftsmanship and<br>understanding of design choices?<br>Did the student engage in reflection and<br>evaluation of their full STEAM process? | <ul> <li>Observation of board construction and painting</li> <li>Self-evaluation and peer feedback on the finished set</li> <li>Group discussion and/or reflection sheet submission</li> </ul>   | <ul> <li>Final printed chess pieces evaluated for:         <ul> <li>Print quality (layer adhesion, stability)</li> <li>Design fidelity (match to digital model)</li> <li>Aesthetic quality (symmetry, creativity)</li> <li>Overall chess set (board + pieces)</li> <li>evaluated using a rubric for completeness, usability, and STEAM integration</li> </ul> </li> </ul> |















|  | □ Optional: video or photo presentation of |
|--|--|
|  | the complete project                       |
|  |  |















## Additional Resources

NOTES:

ACTIVITY SHEETS TO BE LINKED:

EVALUATION MATERIALS TO BE LINKED:

REFERENCES / SUPPORTING MATERIALS TO BE LINKED:

TIME PLAN

Lesson I: Instructional Plan

TEACHING & LEARNING ACTIVITIES MATERIALS (SOFTWARE, HARDWARE) LEARNING OBJECTIVES













| Introduction (5 min)             |
|----------------------------------|
| Learning Activities (15 min)     |
| 3D Modelling Activities (15 min) |
| 3D Printing Activities (5 min)   |
| Wrap-up & Evaluation (5 min)     |

#### Present lesson goals and engage students in initial discussion. Interactive group discussions, practical tasks. Students model chess figures using Tinkercad software. Brief demonstration of 3D printing process. Summary of lesson, Q&A, brief evaluations.



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Clear understanding of objectives and expectations. Engage students in active learning and collaboration. Gain hands-on experience with digital modeling. Basic understanding of 3D printing technology. Confirm comprehension and clarify doubts.

#### LEARNING OBJECTIVES

Clear understanding of objectives and expectations. Engage students in active learning and collaboration. Gain hands-on experience with digital modeling. Basic understanding of 3D printing technology. Confirm comprehension and clarify doubts.

#### LEARNING OBJECTIVES

Clear understanding of objectives and expectations.





MATERIALS (SOFTWARE, HARDWARE) Presentation slides, visual aids





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#### TIME PLAN

Introduction (5 min)

Learning Activities (15 min)

3D Modelling Activities (15 min)

3D Printing Activities (5 min)

Wrap-up & Evaluation (5 min)

TIME PLAN

Introduction (5 min)

**TEACHING & LEARNING ACTIVITIES** Present lesson goals and engage students in initial discussion.

LESSON 2: INSTRUCTIONAL PLAN

Present lesson goals and engage

**TEACHING & LEARNING** 

students in initial discussion.

Interactive group discussions,

Students model chess figures

**ACTIVITIES** 

practical tasks.

MATERIALS (SOFTWARE, HARDWARE) Presentation slides, visual aids Worksheets, chess pieces examples Computers, Tinkercad 3D printer, sample objects

Presentation slides, visual aids

Worksheets, chess pieces

3D printer, sample objects

Discussion prompts, evaluation

Computers, Tinkercad

examples

sheets

Discussion prompts, evaluation sheets

### LESSON 3: INSTRUCTIONAL PLAN





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| Learning Activities (15 min)     | Interactive group discussions, practical tasks.                 | Worksheets, chess pieces<br>examples  | Engage students in active learning<br>and collaboration. |
|----------------------------------|---|---------------------------------------|--|
| 3D Modelling Activities (15 min) | Students model chess figures<br>using Tinkercad software.       | Computers, Tinkercad                  | Gain hands-on experience with<br>digital modeling.       |
| 3D Printing Activities (5 min)   | Brief demonstration of 3D printing process.                     | 3D printer, sample objects            | Basic understanding of 3D printing technology.           |
| Wrap-up & Evaluation (5 min)     | Summary of lesson, Q&A, brief<br>evaluations.                   | Discussion prompts, evaluation sheets | Confirm comprehension and<br>clarify doubts.             |
|                                  | Lesson 4: Inste   | RUCTIONAL PLAN                        |  |
| TIME PLAN                        | TEACHING & LEARNING<br>ACTIVITIES                               | MATERIALS (SOFTWARE,<br>HARDWARE)     | LEARNING OBJECTIVES                                      |
| Introduction (5 min)             | Present lesson goals and engage students in initial discussion. | Presentation slides, visual aids      | Clear understanding of objectives and expectations.      |
| Learning Activities (15 min)     | Interactive group discussions, practical tasks.                 | Worksheets, chess pieces<br>examples  | Engage students in active learning<br>and collaboration. |
| 3D Modelling Activities (15 min) | Students model chess figures<br>using Tinkercad software.       | Computers, Tinkercad                  | Gain hands-on experience with<br>digital modeling.       |
| 3D Printing Activities (5 min)   | Brief demonstration of 3D printing process.                     | 3D printer, sample objects            | Basic understanding of 3D printing technology.           |
| Wrap-up & Evaluation (5 min)     | Summary of lesson, Q&A, brief evaluations.                      | Discussion prompts, evaluation sheets | Confirm comprehension and clarify doubts.                |
|                                  | Lesson 5: Inste   | RUCTIONAL PLAN                        |  |
| TIME PLAN                        | TEACHING & LEARNING<br>ACTIVITIES                               | MATERIALS (SOFTWARE,<br>HARDWARE)     | LEARNING OBJECTIVES                                      |
| Introduction (5 min)             | Present lesson goals and engage students in initial discussion. | Presentation slides, visual aids      | Clear understanding of objectives and expectations.      |
| Learning Activities (15 min)     | Interactive group discussions,                                  | Worksheets, chess pieces              | Engage students in active learning                       |



practical tasks.

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examples

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and collaboration.





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| 3D Modelling Activities (15 min) | Stude         |
|----------------------------------|---------------|
| 3D Printing Activities (5 min)   | Brief         |
| Wrap-up & Evaluation (5 min)     | Sumr<br>evalu |

ents model chess figures Tinkercad software. demonstration of 3D printing ess. mary of lesson, Q&A, brief uations.

| Computers, Tinkercad           | ( |
|--------------------------------|---|
| • •                            | С |
| 3D printer, sample objects     | E |
|                                | t |
| Discussion prompts, evaluation | C |
| sheets                         | с |

Gain hands-on experience with digital modeling. Basic understanding of 3D printing technology. Confirm comprehension and clarify doubts.













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