Teaching Middle School Math with The Geometer's Sketchpad®

COURSE DESCRIPTION
This is a professional level, moderated, online course in the use of The Geometer's Sketchpad software for teaching middle school mathematics. In addition to instruction in how to use the software, the course will offer participants pedagogical guidance on how to implement the use of Sketchpad in their classrooms and promote a discussion of how dynamic mathematics affects the teaching and learning of mathematics. The course runs for six weeks with a scheduled start and end date and is structured into six weeklong units. While participants have flexibility within each week, the course is synchronous, meaning that participants are expected to begin and complete the activities for each week during the week they are assigned. This course is primarily intended for teachers.

COURSE OBJECTIVES
After participants complete this course, they will be comfortable using Sketchpad both as an investigation tool and as a demonstration tool. Participants will be able to:

• Construct geometric figures based on their definitions
• Perform measurements on geometric objects
• Design multi-step custom tools
• Effectively use prepared models to teach concepts in number and algebra
• Apply geometric transformations
• Tabulate and plot data and graph functions
• Create demonstrations that involve animation and action buttons
• Appreciate the pedagogical implications of exploring mathematics in a dynamic environment

INTENDED AUDIENCE
This course is intended for middle school mathematics teachers and instructors of pre-service teachers. Although the course content focuses on middle school concepts, any current or prospective teacher can learn how to use Sketchpad to supplement their mathematics curriculum.

PREREQUISITES
Participants should be familiar with middle school mathematics concepts. They should also be comfortable using computers and must have access to the Internet and The Geometer's Sketchpad Version 4 or later.

METHODS OF INSTRUCTION
Each week follows the same structure in which participants complete these activities:

- Interact with a dynamic sketch that introduces the week's mathematical focus
- Watch two interview videos of Sketchpad developers and classroom teachers (each about 5 to 10 minutes long)
- View between four and eleven tutorial videos (each about 1 to 3 minutes long)
- Read six student worksheets and occasional activity notes of Sketchpad activities
- Complete these six activities offline using Sketchpad
- Participate in an asynchronous discussion forum (as well as an optional scheduled chat)
- Complete a project
- Reflect by responding to specific prompts in an online journal

**GRADE BREAKDOWN**

In order to receive credit for the course, participants must complete all Sketchpad activities, turn in all six projects, respond to all six journal prompts, and participate in the discussion forums at least twice each week. Assessment is project-based and all six weeks are weighted equally.

The two units offered for this course are based upon the expectation that each week will require at least five hours of work (at least two hours for online activities including visual media, discussion forums, and the journal, and at least three hours for offline Sketchpad activities including the project).

Participants will do a weekly activity check that determines their score for working on Sketchpad activities. They will also receive a score for participating in the discussion forum. The moderator will evaluate and provide feedback for projects and journal entries. Grades will be assigned on a standard percent scale based on the following breakdown:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sketchpad activities</td>
<td>20%</td>
</tr>
<tr>
<td>Discussion forums</td>
<td>20%</td>
</tr>
<tr>
<td>Journal entries</td>
<td>20%</td>
</tr>
<tr>
<td>Weekly projects</td>
<td>40%</td>
</tr>
</tbody>
</table>

**REQUIRED TEXTS AND MATERIALS**

All written material will be Sketchpad activities provided as PDFs. These activities come from the online subscription service Sketchpad Lesson Links (2008, Key Curriculum Press), as well as *The Geometer's Sketchpad Learning Guide* by Steven Chanan (2001, KCP Technologies).

**SESSION-BY-SESSION SUMMARY**
Week 1: Geometric Constructions
Using freehand tools and construction commands, participants learn to construct dynamic polygons and explore the relationship between their geometric properties and their construction.

Visual Media:
- "Dynamic Quadrilaterals" JavaSketch
- Interview with Nick Jackiw, "Draw vs. Construct"
- Interview with Lynn Hughes, "A Collection of Tools"
- Tutorial videos (tools, constructions, measurements)

Activities:
- Tour 1: Constructing a Square
- Tour 2: A Theorem About Quadrilaterals
- Meet the Isosceles Triangle: Properties of Isosceles Triangles
- Meet the Parallelogram: Properties of Parallelograms
- Triangle Pretenders: Classifying Triangles
- Quadrilateral Pretenders: Classifying Quadrilaterals

Dynamic Quadrilaterals Project:
Construct special quadrilaterals based on their definitions.

Journal Prompt:
Participants are asked to reflect on the difference between drawing and constructing a rectangle, and whether measurement is needed to verify a construction.

Week 2: Perimeter, Area, and Volume
Participants continue to work on constructions, learn how to use measurement features, including the Calculator, and how to create custom tools in Sketchpad.

Visual Media:
- "Similar Solids" JavaSketch
- Interview with Nick Jackiw, "Sketchpad's Design"
- Interview with Nathalie Sinclair, "Shearing and Dissection"
- Tutorial videos (display options, constructions, Calculator, custom tools)

Activities:
- Double Cross: Angles Formed by a Transversal
- Parallel Pairs: Parallelogram and Triangle Area
- Smoothing the Sides: Regular Polygon and Circle Area
- Scaled Polygons: Effects on Area and Perimeter
- Prism Dissection: Surface Area
- Perfect Packages: Surface Area and Volume

Custom Tools and Calculations Project:
Construct custom tools of special triangles and quadrilaterals. Calculate perimeters and areas form their dimensions and compare calculated values to measured values.

Journal Prompt:
Participants are asked to reflect on the degree to which student learning with Sketchpad will transfer to the mathematics students do away from the computer.
**Week 3: Number and Operations**

Participants explore prepared models that investigate how properties of numbers and operations and learn how to use animation action buttons.

**Visual Media:**
- "Sum and Product" JavaSketch
- Interview with Steve Rasmussen, "Behavior of Operations"
- Interview with Layne Hudes, "Sketchpad and Instructional Time"
- Tutorial videos (animation, action buttons, documents)

**Activities:**
- Tour 3: String Art
- Tour 4: Bestiary of Quadrilaterals
- Number Dials: Bases, Exponents, and Number Systems
- Magic Dividing Machine: Exploring Division
- Algebars: Exploring Properties of Operations
- Right or Left: Adding and Subtracting Integers

**Dynamic Number Line Project:**
Create a number line that models the behavior of each of the four arithmetic operations.

**Journal Prompt:**
Participants are asked to reflect on how animation can be used to deepen mathematical understanding.

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**Week 4: Coordinates and Transformation**

By focusing on a variety of activities involving reflections, translations, rotations, and dilations, participants investigate how to use Sketchpad to explore and apply transformational geometry.

**Visual Media:**
- "Tessellations" JavaSketch
- Interview with Nathalie Sinclair, "Transformations and Tessellations"
- Interview with Karen Wyatt, "Fostering Student Creativity with Projects"
- Tutorial videos (coordinates, transformations)

**Activities:**
- Tour 5: Reflection + Reflection = ?
- Number Flips: Reflections in the Coordinate Plane
- Number Slides: Translations in the Coordinate Plane
- Menagerie: Comparing Transformations
- Dilation Designs: Proportions in Similar Polygons
- Squaring the Sides: The Pythagorean Theorem

**Ferris Wheel Project:**
Create tessellations based on translation and rotation.

**Journal Prompt:**
Participants are asked to reflect on how transformational geometry is related to other topics in middle school mathematics.

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**Week 5: Multiple Representations**
Participants learn how to move between different representations in Sketchpad, including how to work with tables, use the coordinate grid, and create and plot functions.

Visual Media:
- "Square Data" JavaSketch
- Interview with Nathalie Sinclair, "Teaching Sketchpad to Calculate Slope"
- Interview with Mary Wiltjer, "Appealing to Different Learning Styles"
- Tutorial videos (functions, parameters, tables)

Activities:
- Tour 7: Algebra Potpourri
- Reach the Target: Developing Concepts of Slope
- Hikers: Solving Through Multiple Representations
- Circle Roundup: Circumference to Diameter Ratio
- Mellow Yellow: Interpreting Graphs
- Mean Meets the Median: Measures of Central Tendency

Dilation Data Representation Project:
Gather measurements of a geometric object and its dilation. Represent the data in a table, as plotted points, and as a function.

Journal Prompt:
Participants are asked to reflect on sample teaching resources and ideas that may address the challenges they may encounter as they begin to integrate Sketchpad into their teaching.

Week 6: Equations, Inequalities, and Polynomials

Participants focus on prepared models that help students understand the concept and process of solving equations and inequalities, as well as quadratic functions and polynomial products.

Visual Media:
- "Approximating Solutions" JavaSketch
- Interview with Nick Jackiw, "Parents and Children: A Hierarchy of Relationships"
- Interview with Kelly Clark, "Introducing Sketchpad to Students"
- Tutorial videos (properties, preferences)

Activities:
- Undoing: Solving Linear Equations
- Balancing with Balloons: Solving Equations with Negatives
- Shady Solutions: Graphing Inequalities on a Number Line
- In or Out: Graphing Inequalities
- Tiling in a Frame: Multiplying Polynomials
- Rooting for Roots: Factoring and Graphing Quadratics

Final Project:
Create a sketch with animation that can be used as a demonstration tool in a mathematics class.

Journal Prompt:
Participants are asked to reflect on how Sketchpad may address concepts that students find difficult to grasp.