Geometrical Manipulatives in WME

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Topics
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• Authoring Manipulatives
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What you will learn
• After the tutorial, you will know
  – The role manipulatives play in WME
  – How to use manipulatives in WME topic lesson pages
  – How to author geometrical manipulatives by using the authoring tool GeoSVG
  – How to deploy manipulatives you create
  – How to customize manipulatives

Background
• WME offers classroom-ready lessons (topic lesson pages) that host the manipulatives

Warm-up: Manipulative you can create by yourself
• Experiment 0: construct a perpendicular line of a segment through its mid-point
• Steps
  1. Draw a segment
  2. With the segment selected, construct its midpoint
  3. With the segment and the midpoint selected, construct a perpendicular line
• Test: drag any object around to see the mathematical relations are maintained
Need for Manipulatives

- Manipulatives enable students to have active involvement to enhance learning
- Manipulatives can make students to move to higher levels of conceptualizing and begin to integrate spatial and symbolic mental representations
  - Success of Logo, one of the earliest interactive program
- Geometric manipulatives covers important areas in math teaching
  - Plane geometry, algebra, trigonometry, calculus, statistics, and so on (snapshots in next slides)

Figure 1: Geometric Manipulative in Trigonometry
- Definition of sine function (opposite side/hypotenuse)

Figure 2: Geometric Manipulative in Algebra
- Fixed point of function $f(x) = \sqrt{x}$

Figure 3: Geometric Manipulative in Plane Geometry
- How to construct a circle through three points

Figure 4: Geometric Manipulative in Calculus
- Approximate the integral of a function

Figure 5: Geometric Manipulative in Statistics
- Box and Whisker
Need for Manipulatives (cont.)

• Advantages of manipulatives over physical drawings
  – able to draw an entire set of similar cases in seconds
    • Example: Construct a circle through three points.
    • Circle is larger than a scratch paper when three points are almost co-linear
  – able to visualize the transitions between cases
    • How does the circle change when points are moving
  – easy to repeat
    • Approximate the area under a curve by drawing rectangles
  – easy to represent algebraic relations between geometrical objects
  • Measurements can be updated dynamically

Manipulative Examples in WME Pages

• Components of a WME Topic Lesson Page
  – Text
  – Manipulative(s)
  – Question set(s)
• Examples (snapshots: next a few slides)
  – Plane Geometry example
    • Area of a Triangle (generated by GeoSVG)
  – Algebra example
    • Walking wolf over a number line (ad hoc program)
  – Statistics example
    • Box-and-Whisker (generated by GeoSVG)
  – Number relation example
    • Meaning of equal (ad hoc program)
Authoring Manipulatives

- Two ways to create manipulatives
  - By writing ad hoc programs by software developers
  - By using authoring tool
- A large category of manipulatives, especially those related to geometry, can be authored by using Dynamic Geometry Software (DGS)
  - A DGS system supports diagramming, interactive learning, and easy authoring of geometrical manipulatives
  - Successful DGS systems: Geometer SketchPad, Cabri Geometry II, and Cinderella
- We are developing our own DGS system GeoSVG
  - Reason to develop our own DGS system: its complete Web-orientation

Authoring Manipulatives (cont.)

- Steps to access GeoSite and the authoring environment
  - Open page http://wme.cs.kent.edu/geosvg/software.html
  - Follow the link in the page to GeoSite
  - Log into GeoSite (10 accounts are already pre-registered and will be assigned to the participants of the tutorial)
  - Now you are at your home folder
  - Next slide shows possible operations on GeoSite
  - Either authoring a new manipulative or editing an existing manipulative will open the authoring environment

Authoring Manipulatives (cont.)

- GeoSVG authoring environment
  - Canvas: a bounded area in which to create manipulative
  - Toolbar: basic drawing tools and property dialog box
  - Menu: providing various authoring supports listed in next slides
- Authoring procedures
  - GeoSVG Authoring Environment
  - Save manipulative to your current folder
  - GeoSite
  - Authoring procedures
  - GeoSVG: copy manipulative to your current folder

Authoring Manipulatives (cont.)

- GeoSVG Architecture and Components
  - The GeoSVG toolkit — an SVG-coded library for authoring (creating, editing, publishing plane geometry manipulatives and for their display, animation, and user interaction).
  - The GeoSite — a Web site that makes the GeoSVG toolkit available and stores manipulatives for access, searching, and sharing.

Figure 10: GeoSite Operations

Figure 11: The GeoSVG Authoring Environment
Authoring of Manipulatives (cont.)

- **Authoring Supports**
  - **Drawing primitives:** Making it simple to create basic geometric shapes such as points, lines (segments, rays and vectors), circles (ellipses and arcs), polygons, etc.
  - **Geometric object construction:** Constructing a new geometric object by combining existing objects that are subject to user-specified rules and constraints. For example, picking a point and a line to construct a new line through the point parallel to the existing line.
  - **Measurement:** Measuring length, slope, radius, distance, area, circumference, perimeter, angle, coordinate positions.
  - **Loci and Envelops:** Constructing loci of moving points and envelopes of moving lines.
  - **Animation:** Visualizing the movement of objects to illustrate concepts much better than still pictures.

- **Authoring Supports (cont.)**
  - **Iteration:** Generating a sequence of objects according to iteration rules defined by a user.
  - **Calculation:** A dynamic calculator updates results when statuses of dependent objects change.
  - **Graphing:** Plotting points and function graph in coordinate systems.
  - **Geometric transforms:** Allowing users to define center and mirror for translation, reflection, dilation, and rotation of objects.
  - **Defining Macros:** Condensing a series of steps into one software command.
  - **Graphical User Interface (GUI):** Combining menus, buttons, mouse actions, and keyboard inputs to provide an intuitive and convenient authoring environment.

Authoring hands-on Experiments

- **Authoring hands-on Experiments**
  - Now I will guide you through how to author manipulatives

  - **Experiment 1:** construct a circle through three points
    - **Steps:**
      1. Draw three points and connect them by two segments
      2. Select one segment and construct its midpoint from the construct menu; do the same thing for another segment
      3. Select the segment and its midpoint; construct a perpendicular line to this segment and through the midpoint; do the same thing for another segment
      4. Draw the intersection point of the two perpendicular lines
      5. Draw a circle with the intersection point as the center and through any of the three points
    - Objects can be labeled via the property dialog box
    - Drag any object to move around to see how mathematical relations are maintained

  - **Experiment 2:** Area of a Triangle
    - **Steps (continued)**
      7. Construct a movement button for merging two triangles into a parallelogram
        - Even number of points must be selected when movement button is to be created. A movement button moves the first point of each selected pair toward the second.
        - In order to move one side of a triangle to one side of another triangle, there must be two source points and two destination points
        - The point of type PivotPoint must be one of the source points because moving it will translate the triangle. In the example, E is the point of type PivotPoint.
        - In the example, four vertices selected in order are D, B, E, A, where D, E are the source points, and B, A are the destination points.
Deploying Manipulatives in WME pages

- Let’s use one manipulative you just created to deploy it in a WME page.
- Page editing allows you to enter the URL of the manipulative located in GeoSite.
- Test the page:
  - Great! You have made contribution to the WME system.

Customization of Manipulatives

- Manipulatives are customizable:
  - Like other components in a TLP, a manipulative can also be tailored to a desirable configuration by teachers.
  - This is significantly different from other computer games or software for math teaching, which are fixed.
- Each manipulative is associated with an xml file, which saves all the configurable parameters.
- Customization example (next slide).

How to contact us for further collaboration

- WME Home: http://wme.cs.kent.edu
- Project Personnel with Contact information:
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