Analysing design problem solving products as external representations

Erica de Vries
Laboratory for Educational Sciences, UPMP-JUFM
University of Grenoble II, France

External representations in design

- Definitions of representation
  - Something that stands for something else (to somebody)
  - Making present something absent

- Design = the construction of the plan of an object that will satisfy some need
  - Involves multiple external representations
    - Text, drawings, diagrams, measurements, computer graphics
    - In domain-specific formats
      - Lists, technical drawings, flowcharts,

A view on learning and design

- Opposite processes with respect to three domains?
  - The mental, the symbolic and the material domain

  - Need for semiotics
    - The study of cultural conventions in meaning making
    - A representation is meaning making in the same semiotic system (Cox, 2007)
    - System or not for objective reasons (if stop means go) but code a matter of no versus green

Palmer’s features (1978) applied to design

<table>
<thead>
<tr>
<th>Represented world</th>
<th>Aspects represented</th>
<th>Representing world</th>
<th>Aspects representing</th>
<th>Correspondence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial relations</td>
<td>Geometry</td>
<td>Lines, line width and style, angles, data, shades, gradients, forms, profiles, relations</td>
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<td></td>
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<tr>
<td>Material characteristics</td>
<td>Graphical code</td>
<td>shaded, shaded, smooth, gradients, forms, profiles, relations</td>
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<td></td>
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<tr>
<td>Integrated artifacts</td>
<td>Functional aspects</td>
<td>Technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description, illustrations</td>
<td>Discourse, Word, phrase, Semantics</td>
<td>Visual resemblance</td>
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</table>
A preliminary inquiry

- Into the representational formats used by different types of students in solving a design problem
  - How do they express geometrical and functional information?
  - To what extent do they vary between and within groups?

- Corpus
  - Drawings and textual comments produced by students from different backgrounds for a student residence problem
  - 16 fourth year university students in educational science
  - 37 secondary school students in vocational training

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Student-residence problem (Bookholdt, 1984)

- Design at least three different layouts, describe them and give order of preference with argumentation
  - On white or squared paper
  - A 3-dimensional projection drawing showed the form and dimensions of the room and the available furniture
    - Dimensions were chosen so that common or obvious floor plans were problematic from a user's point of view
      - Bed below the window
      - Furniture blocking door or window
      - Impossible to open the cupboard
      - Too little space for sitting at desk

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"Rational" layouts

- Schematic drawings
  - Not pictorial
  - No reference of size
- Geometrical characteristics
  - 2D scale drawings
- Functional characteristics
  - Footprint showing constraints and space and foot press
    - Access to door and window
    - Heating and light on desk
    - Room to move around
    - Not neglecting silence
    - Space for sitting at desk
    - Space for opening window
    - Cleaning maintenance
    - Smiling friends
4th year students in education

- Resemble the rational layout
- Schematic drawings
- Geometrical information
  - 100% 2D drawings
  - 50% scale drawings
  - 100% physically possible
- Functional information
  - In simple tests
  - Mention 2 to 7 different functions (mean = 3.5)
  - 38% showed user problems
  - 11% of non-scale drawings

<table>
<thead>
<tr>
<th>Function</th>
<th>Mentioned by</th>
</tr>
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<tbody>
<tr>
<td>Access</td>
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<tr>
<td>Work</td>
<td>94%</td>
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<tr>
<td>Move around</td>
<td>88%</td>
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<tr>
<td>Store</td>
<td>56%</td>
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<tr>
<td>Rest</td>
<td>38%</td>
</tr>
<tr>
<td>Pleasant stay</td>
<td>19%</td>
</tr>
<tr>
<td>Maintenance</td>
<td>13%</td>
</tr>
<tr>
<td>Invite friends</td>
<td>13%</td>
</tr>
</tbody>
</table>

Secondary school students in vocational training

- Large variety of productions
  - Schematic, technical and pictorial
- Geometrical information
  - 35% 2D, 35% 3D, and 35% mixed
  - 28% scale drawings
  - 75% physically possible
- Functional information
  - Not much test
  - Schematic, technical, and pictorial 2D and 3D
  - Mention 2 to 7 different functions (mean = 3.5)
  - 38% showed user problems
  - 11% of non-scale drawings

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<thead>
<tr>
<th>Function</th>
<th>Mentioned by</th>
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<tbody>
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<td>Access</td>
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<tr>
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<tr>
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</table>
**A conclusion & further research**

- Complex relations between chosen representational format and physical and functional soundness
  - For the university students
    - The most preferred representation is 3D schematic drawings, but this does not prevent user problems. Functional problems seem to be more likely to arise in scale drawings.
  - For the secondary school students
    - Several representational strategies exist; 2D scale drawings seem to be more likely to show physical and functional problems.
- Emerging research questions
  - What influences choice of a representational format?
  - What explains the situation and problem statement?
  - What explains individual differences?
  - Vicariness, e.g., interchangeability of cognitive processes for determining actions in a given situation.