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Mining Montessori Design Patterns

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A pattern language is a way "to organize implicit knowledge about how people solve recurring problems when they go about building things" (Alexander). Pattern languages are used extensively in architecture and software development to share knowledge about designed elements in those domains.

In a sense, pattern languages are like the Montessori teacher's albums. The albums capture Montessori community knowledge about materials, activities, teacher and student roles, norms of behavior, and learning goals. The individual writeups in the teacher's album are related in a web of activities that support one another. A pattern language consists of a web of individual design patterns.

But pattern languages are concerned with the *design* of a class of elements that belong to a particular kind of environment. Albums capture knowledge about the *use* of designed elements in a Montessori environment. A Montessori pattern language would capture knowledge for about the *creation* of designed elements for a Montessori environment.

Design patterns are often written as problem/solution pairs together with one or more examples of designs in which the pattern is used. To contrast the writeup of an activity in a Montessori teacher's album with a Montessori design pattern, contrast the activity writeups Colored Sectors (Leone, 2004b) and Fraction Circles And Polygons (Leone, 2004c) with the design patterns I list in Montessori Design Patterns (Leone, 2004d). For an example of an application of a Montessori design pattern to a specific design, see Colored Sectors: Applying a Montessori Design Pattern to the Problem of Angle Representation (Leone, 2004a).

The design patterns I listed in Montessori Design Patterns (Leone, 2004d) are based on the Montessori knowledge that I picked up through training, classroom experience, observation, and examination of Montessori materials. They are also limited in scope, applying almost exclusively to materials. They do not, of themselves, constitute a pattern language.

To create a Montessori pattern language, we would have to map out the whole space in which Montessori designs appear. How do we figure out what should be included in this space and how it should be organized?

The designed elements that concern architects are various kinds of structures. Design patterns are organized at various levels, including the level of rooms, building, neighborhoods, and towns (Alexander, Ishikawa, & Silverstein, 1977). In software design, designed elements might include classes, interface elements, or interface interactions.

In the realm of Montessori education, we can certainly consider the didactic materials as designed elements. But what about specific exercises as they written up in albums? As Sonja Donahue says, "[process and materials] are so intermingled that to separate them would be artificial, and would give a false perspective on the planning and execution of an exercise" (Donahue, 1974).

What about things like organizational standards, school policies, school architecture and landscaping, ground rules for a classroom, classroom layout, forms or other artifacts that support assessment, and rotation of materials? All of these things can be considered as designed elements of the Montessori environment—they are all designed by humans.

It is my belief that we cannot organize Montessori design patterns into a pattern language until we have mined a significant number of design patterns. However, there are ways to ensure that we cover a significant portion of the design space. In this paper, I will suggest a way to use of the work models of Beyer and Holtzblatt (Beyer & Holtzblatt, 1998) to ensure this coverage.

Beyer and Holtzblatt advocate the use of ethnography to capture knowledge about work environments for the purpose of designing custom software. They suggest five different models of work: the flow model, the sequence model, the artifact model, the cultural model, and the physical model. In the sections that follow, I will discuss each model and give at least one example of a design pattern that might be extracted from the model.

Flow Model

The flow model deals with conventions that have been designed around work flow. To mine patterns related to this model, we need to ask questions like:

- What are the responsibilities of the teacher and the student in the Montessori classroom?
- How do tasks get assigned to students and teachers?
- Where do students and teachers go for help?
- Who do they work with to accomplish their tasks?
- How do they use physical places and artifacts to help them coordinate?
- Who do they give the results of their work and in what form?

Below are examples of design patterns that could be derived from a flow model of a Montessori classroom.

Defining Work Space

Design problem: Materials and children occupy space. In order to freely engage in activities, children need an unobstructed work area. Freedom of movement further requires that children are not tied to a specific place in the room.

Design solution: Give children a mobile instrument that defines their work space and establish a classroom norm that other children cannot enter the defined space without being invited.

Example: Small rugs that children can place on the floor together with the classroom norm that the child's material remains on the mat, others cannot step on the mat, and others cannot join the child without the child's invitation. Table mats can be used in a similar way.

Autonomy with Responsibility

Design problem: If we impose a particular curriculum without regard to the individual child, we will not discover what potentials might have been realized through spontaneous activity. On the other hand, neither will the child reach her potential if we leave her to act according to any random impulse.

Design solution: Make a range of didactic materials available. Allow children to choose their material according to guidelines that help assure the appropriate level of challenge. Carefully observe the child's use of these materials, facilitating use as needed and suggesting use of

materials that appear to match the interests and performance level of the child. Require of each child that they not harm themselves or others, interfere with the work of others, or damage materials. Child and teacher may also enter into child-appropriate agreements about work to be accomplished.

Example: This is the setup of a typical Montessori classroom. Some of the language in the design solution is purposely vague because this is a high-level design pattern. John Chattin-McNichols has collected data on teacher interventions (Chattin-McNichols, 1992) that indicate that they are consistent across countries and Montessori organizations. Specific intervention situations could be used in lower level design patterns. In other places in the design solution, the language is vague because I don't have data. For example, a particular teacher, recognizing that one child's parents are going through a difficult divorce, might consider it appropriate for that child to seek out familiarity in repetition of tasks that she has already mastered. I don't have data at this level of the interpretation of "appropriate level of challenge" by Montessori or Montessori professionals. I also know that some teachers in elementary classrooms enter into more or less formal agreements with students about work to be accomplished, but I don't know how widespread or standardized this practice is.

Note that the "Autonomy with Responsibility" pattern is a "large" pattern which contains many "smaller" patterns, including the "Defining Work Space" pattern and the patterns regarding teacher intervention that are suggested in the example above.

Sequence Model

The sequence model shows how tasks are carried out in a step-by-step fashion. For this model, we might consider:

- What are the intents of the child in selecting and carrying out a particular activity? Some possible intents include aesthetic enjoyment, enjoyment of a challenge, an opportunity for companionship, a way to avoid activity suggestions from a teacher.
- Why does the child perform a given task in the way that she does?
- What are the intents of the teacher in engaging in a particular demonstration, observation, or intervention?
- Why does the teacher perform a given task in the way that she does?
- How does the environment support or discourage these intents?

Here is an example of a design pattern that could be uncovered with the sequence model:

Limit Possible Moves

Design problem: For the child to learn from some material (Montessori material, textual material, software, or other learning material):

- The material must initially confront her with something she does not understand. If the material makes perfect sense from the start, there is nothing to be learned from it.
- There must be distinct problem and resolution states that the child can identify as such. Otherwise, the child would have no way of knowing if understanding was achieved.
- There must be some kind of support for the child to move from the problem state to the resolution state. If support were not needed, the child would already understand the problem, so no learning could occur.
- The support must allow alternative moves from problem state to resolution, some of which achieve resolution, and some of which do not. If all moves are forced, there is no need to "figure out" a path from the problem state to the resolution, no need to think, and no need to learn.

Notice that these requirements hold for any learning material, not just Montessori material. Montessori's particular way of meeting these requirements is the subject of the rest of this study.

Design solution: Create materials that permit some moves and not others. When the child attempts a move that is impossible, she will be confronted with something she does not understand. The solution state is some subset of the permitted moves. Disallowing certain moves provides support in moving from problem state to resolution state. Allowing

attempts at impossible moves provides opportunities for alternative moves.

Example: Geometric insets only allow insertion of matching figures. Knobbed cylinders only allow insertion of cylinders into holes with wider diameter than the cylinder, and there is only one arrangement in which all cylinders fit into all holes.

Note that this is only one solution to a broad problem. This pattern could be subsumed under a "larger" pattern – "Introduce Opportunities for Hesitation and Error with Scaffolding"—in which we consider the general issue of providing challenges to students and supporting their work on these challenges.

Artifact Model

The artifact model is concerned with things that are created, used, and modified in the workplace (Beyer & Holtzblatt, 1998). In the Montessori classroom, the most obvious of these are the didactic materials.

Below is a design pattern that could be extracted from the artifact model (Leone, 2004a). A number of design patterns from the artifact model can be found in Montessori Design Patterns (Leone, 2004d).

Variable Sequencing

Design problem: We want to help the child recognize and construct understandings about attribute X. However, pairing objects will not highlight attribute X because we cannot create an object with attribute X that does not also have attribute Y, so children will be apt to confound attributes X and Y.

Design solution: If attributes X and Y can both be graded, make four sets of objects that are graded as follows:

Set 1: Objects can be graded in increasing order by both attribute X and Y.

Set 2: Objects can be graded in increasing order by attribute X. Attribute Y remains constant.

Set 3: Objects can be graded in increasing order by attribute Y. Attribute X remains constant.

Set 4: Objects can be graded in increasing order by attribute X and, simultaneously, in decreasing order by attribute Y.

Example: Knobless cylinders. In this case, attribute X is diameter and attribute Y is height. Set 1 corresponds to the yellow cylinders, set 2 to the red cylinders, set 3 to the blue cylinders, and set 4 to the green cylinders.

Cultural Model

As stated by Beyer and Holtzblatt "work takes place in a culture, which defines expectations, desires, policies, values, and the whole approach people take to their work" (Beyer & Holtzblatt, 1998),.

Montessori culture can be considered on at least three levels—the classroom culture, the school culture and the culture of Montessori organizations. The classroom culture includes norms such as "Once each child has chosen what to do and has chosen the material and the activity, for the length of time the child is doing it, the materials and that activity are owned by that child. Once the material is returned to its proper place, its ownership again reverts to the whole group" (Rambusch & Stoops). The school culture determines such issues as whether the school will seek accreditation and from which Montessori organization it will seek accreditation, what background is required of its teachers, and the level of orthodoxy of the school. The culture of the Montessori organization includes the questions what it will require of the schools and teachers it accredits.

Here is a design pattern that might be extracted from the cultural model:

Authenticity

Design problem: Montessori developed a specific set of materials and practices for the Case de Bambini. She was also an innovator who went beyond the work of earlier to innovators to develop her own method of supporting the physical, intellectual, and spiritual growth of children. To be authentic Montessorians, do we use Montessori's materials and practices exactly as she proscribed, or do we try to develop further innovations based on her work? If we innovate, how do we verify the quality of our innovations in light of Montessori's work?

Design solution: Solutions vary. According to Nancy Rambusch, "American Montessori educational practice may be considered, much like American Judaism, on a continuum. The most orthodox practice emanates from Montessori's circle of European disciples, while the "reformed" practice, although proceeding from Europe, is indigenous in origin and assimilationist in intention. Some American Montessorians see the original San Lorenzo Children's House of 1906 as their model; others see Montessori's insights as more critical than the full panoply of her didactic materials. Montessori practices reframed by time, circumstances and cultureare the *foci* of such Montessorians" (Rambusch & Stoops).

Example: In *The Authentic American Montessori School: A Guide to the Self-Study, Evaluation, and Accreditation of American Schools Committed to Montessori Education*, a publication of the American Montessori Society, Nancy Rambusch says, "The authors of this *Guide* are among those who believe that the authenticity of Montessori's methods does not derive from an exact replication of every facet of her historical work, or from the work of those who implemented her ideas. Apart from believing that it is

Montessori's principles rather than her specifically designed artifacts that are central to her pedagogy (Rambusch 1978), the "reform" Montessorians, among whom the authors count themselves, have no quarrel with the original orthodoxy" (Rambusch & Stoops).

Managing Limited Resources

Design problem: The amount of space and materials within a classroom is limited. Further, children should learn to cooperate with others and to manage time and resources.

Design solution: Establish norms of ownership and cooperation.

Examples: Once a child has taken out a material, it belongs to that child until she puts it back. A child may not work with another child's materials unless invited to do so. If a child takes a material out, the child must put that material away before taking out something else.

Physical Model

This model is concerned with the physical layout of the work space that can support or obstruct work (Beyer & Holtzblatt, 1998).

Here is a Montessori design pattern related to the physical environment:

Providing access

Design problem: To allow for spontaneous activity, children must be able to retrieve and replace materials on their own.

Design solution: Put materials in an accessible place. Arrange the materials to facilitate selections that match the child.

Examples: Montessori materials are generally arranged on low shelves. Materials concerned with different subject matter are placed in different areas of the room. Within an area, materials are placed in order by level of difficulty.

Architect Victor Sidy has defined a number of design patterns for Montessori classrooms, including "the indoor-outdoor continuum, light from multiple sources, sourth-facing outdoors, and north-side protection" (Sidy, 2003).

Did we get everything?

Although it gives us pretty good coverage of the designed elements that affect the Montessori classroom, there will likely be important design considerations that are not captured by the Beyer & Holzblatt work model. There are other ways to represent ethnographic data that can be useful to designers, and there is much in the rich work descriptions of ethnographers that would be lost if they were limited to representations in the form of problems and solutions (Martin, Rouncefield, Rodden, Sommerville, & Viller, 2001).

For example, we would lose descriptions of unsolved problems. Beyer and Holtzblatt (Beyer & Holtzblatt, 1998) use the concept of breakdowns to identify potential areas of focus for software designers. In the work context, breakdowns are observed instances of hesitation or error. Ethnographers (Martin et al., 2001) have begun work on using ethnography to mine other patterns that don't fall neatly into the problem/solution template. Patterns without clear solutions are especially valuable to those interested in developing classroom innovations.

Classroom designs could also be informed by looking beyond the classroom. For example, designs of math materials could be informed by patterns of work done by mathematicians, or by users of mathematics from actuaries and engineers to house managers balancing checkbooks, or by examination of the life of the child beyond classroom walls.

Still, I believe that the Beyer & Holzblatt work models could be used to extract a significant set of design patterns that could be used to map out the space of a Montessori pattern language, and fill in a substantial part of it.

What Next?

As a significant number of design patterns are defined, we can begin to organize them into a design language. One way to organize them might be to divide them according to Beyer and Holtzblatt's work models. However, there will likely be considerable overlap between patterns extracted from the different models. Another approach might be to classify patterns in terms of physical objects (materials, artifacts used by teachers, classroom layout and design) with reference to relevant flow, sequence, and cultural elements supported by the physical objects. Or we might group patterns according to classes of activities. Levels of patterns might be determined by physical characteristics (e.g., a classroom contains materials, so classroom patterns would be considered as a higher level of patterns) or by other criteria, such as John Chattin-McNichols classification of elements of Montessori into theory, model and practice. Or some reasonable organization may emerge.

We also need a clearly defined Montessori approach to testing new designs or refinements of existing design. Discussions with the design-based research community might be fruitful toward this end (The Design-Based Research Collective, 2002).

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