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# DESIGNATION – Lessons in Digital Construction from Villa Mairea

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TERMS:

**design** to conceive and plan out in the mind

**designation** the act of indicating or identifying

ABSTRACT:

The paper will consider the role of digital tools in the design and detailing process from the perspective that architectural software should (1) automate menial and repetitive tasks, (2) make difficult tasks easier and (3) suggest new possibilities, all in the service of promoting design rather than economy and humanity over technology.

Specifically, architectural software known as Building Information Modeling (BIM) has become increasingly populated with pre-designed building elements such as doors, windows, and columns. Architecture students are particularly susceptible to simply *designating* these elements for their design proposals rather than *designing* them or even making significant modifications. The ease with which these common and often poorly designed elements are inserted into otherwise thoughtful works of architecture invites criticism and reinforces the importance of design of a wide variety of building elements at a variety of scales.

Alvar Aalto's canonical Villa Mairea, deliberately addressed the tension between humanity and technology, using industrially available elements selectively and usually with considerable modification. Villa Mairea thus serves as a foil against the tendency to designate standardized architectural elements provided in the libraries that accompany Building Information Modeling (BIM) software.

The use of computers has clearly transformed both architectural practice and architectural education as “traditional production tools (pencils, slide rules, triangles) have now substantially be superseded by more streamlined and efficient ones embedded in computer software.”<sup>1</sup> Architect and educator Juhani Pallasmaa notes that the shift from physical to digital tools for architects “was presented as a solely beneficial invention that liberated human fantasy,”<sup>2</sup> but warns that while “we acknowledge the benefits of the computers and associated digital technologies, we need to identify the ways in which they differ from previous instruments of design.”<sup>3</sup> This is an important challenge, asking architects to be deeply critical of digital tools. As futurist Kevin Kelly writes, “We need to civilize and tame new inventions in their particulars. But we can do that only with deep engagement, firsthand experience, and a vigilant acceptance.”<sup>4</sup> Instilling this critical instinct in students is an essential part of architectural education today, given the growing presence and capability of computers, and the tendency to replace design with designation.

Computers were developed throughout Aalto's adult lifetime but he never faced the prospect of having computers in his office. Almost immediately after his death in 1976, computers proliferated with “the introduction of the first IBM PC in 1981 that set the stage for the large-scale adoption of CAD. The following year, a group of programmers formed Autodesk, and in 1983 released AutoCAD, the first significant CAD program for the IBM PC.”<sup>5</sup>

Even the earliest digital tools were intensely complicated, using tens of thousands of lines of code in computer programming languages. Ever-increasing complexity and the language barrier between software developers and architects makes it almost impossible for architects to modify their digital tools directly. Instead, software developers offer ways for users to provide feedback and participate in testing, creating a slow and homogenized evolutionary process. Fortunately, it is unnecessary to make one’s own tools to influence their evolution, but it is necessary to master their use to do so. Unless architects can master the tools at their disposal, the nature and capacity of the tools themselves will be inevitably determined by others. The implications are significant as our tools inevitably affect how we work and what we make. As architect and author Richard Garber warns, “The consequences of how we consider problems of design with (digital) tools will have an impact on what buildings look like and how they perform, thereby charting a new course for contemporary architectural practice.”<sup>6</sup>

Certainly the digital toolkit of architects is expanding, but rarely through the advent of new tools made specifically for architects. Rather, architects have tended to adopt software originally intended for other disciplines. AutoCAD is perhaps the most widely used (or misused) computer program for architects but was originally developed as a drafting program. Drafting is understood as a technique deployed by architects but it hardly attempts to capture how architects think. Garber rightly notes that, “the first CAD packages were a sort of analogue for what designers traditionally did manually, meaning that they provided a virtual working environment; however they did very little to challenge the design process itself. CAD simply changed the medium of architectural production from a physical one to a virtual one.”<sup>7</sup>

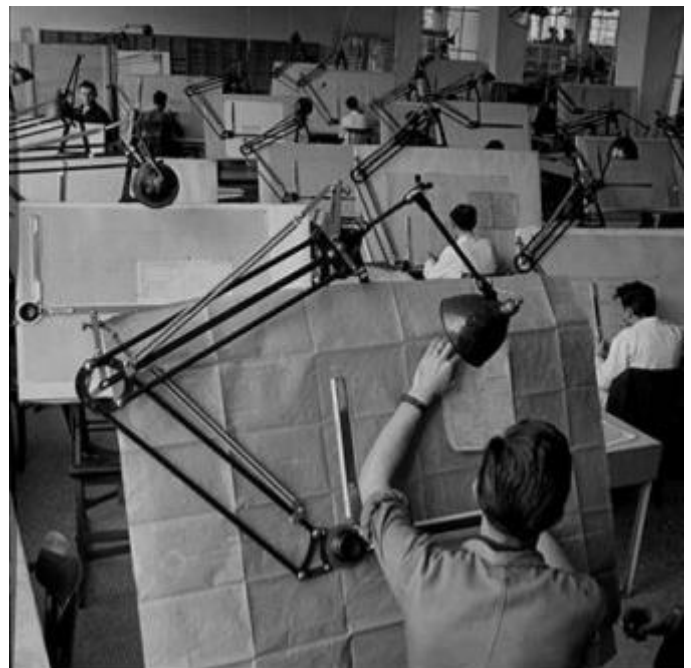


Figure 1 Drafting room, Olivetti typewriter factory, 1947 / Calma Digitizer drafting computer, late 1970's

Perhaps the most prominent example of this transposition in digital tool usage is Frank Gehry's adoption of CATIA®, software created by French aerospace company Dassault Systemes® to resolve complex curvature in the metal skins of aircraft into panels. This arguably uses the software for the purpose for which it was designed, though for a different product. In a sense, this willingness to adopt tools designed for other disciplines illustrates a kind of evolution, but it is an evolution of format rather than an evolution of function.

Although architects readily adopt technological developments to improve efficiency for existing tasks, they can also predict the need for digital tools that do not yet exist. As architectural theorist Robert Somol recognized, architect Peter Eisenman's "transformational diagramming techniques anticipate the need for (and predict the possibilities of) the later development of 3D modeling and animation software."<sup>8</sup> This is not to say software was developed specifically to accommodate Eisenman's process, but rather to enable a way of thinking three and four-dimensionally that is common but not exclusive to architects.

A few software programs are now being developed specifically for architects and in turn for architecture students. One category of architectural software developed for architects intensely at the turn of the 21st century is known as Building Information Modeling (BIM). Working from the premise of digitally constructing an entire building at full scale, "building information modeling (BIM) provides ... the ability to digitally coordinate the often-complex process of building prior to actual construction."<sup>9</sup> Architectural drawings are created by controlling how the digital model is seen, often through the use of architectural conventions which are built into the software.

BIM is understandably geared towards the broadest segment of the market of practicing architects. Use of BIM has increased rapidly and is expected to be an \$11 billion industry by 2022.<sup>10</sup> Though determining market share precisely is currently not possible, Autodesk Revit® is generally accepted as the most popular BIM platform for architectural practice. By focusing on the features most desired by architecture firms in practice, BIM becomes less suited for students but is by no means unusable and has many features that are incredibly useful. To clarify, BIM doesn't prevent the design of architectural elements and details, but comes loaded with extensive libraries of elements that are tempting substitutions for design. Architecture students are most vulnerable to this temptation given their limited experience. Garber

recognizes that "a number of building product suppliers have already made available libraries of products such as windows doors and railings, most commonly in Autodesk Revit® file format. Such openness should be received with both caution and embrace – while the idea that architectural design can be reduced to the selection and organization of pre-existing building components that effectively negates the authorial creativity."<sup>11</sup>

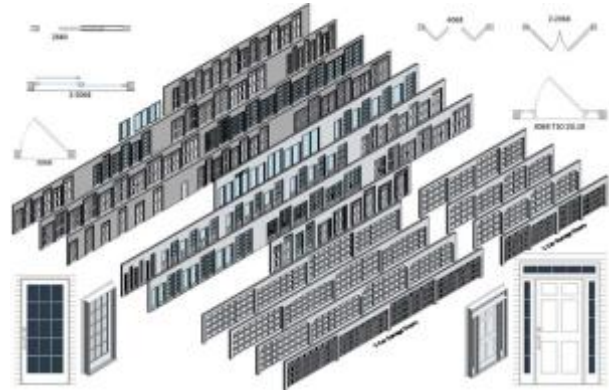


Figure 2 Revit door library

Though seemingly convenient, selecting elements from predefined lists presents a false choice, especially to students with limited experience. As technological ethicist Tristan Harris explains, "When people are given a menu of choices, they rarely ask: 'What's not on the menu?'; 'Why am I being given these options and not others?'; 'Do I know the menu provider's goals?' and, 'Is this menu empowering for my original need, or are the choices actually a distraction?'"<sup>12</sup> The elements in question that populate software libraries are surely curated towards the convenience and economic benefit of the primary users: practicing architects. By simply selecting from a predefined menu, users accept the agenda of the software creator and in turn the economics driving contemporary architectural practice. Without an in-depth knowledge or even mastery of the software in question, it is difficult to recognize what choices are not included.

For students who are inevitably learning new software while learning to design architecture, this temptation is almost overwhelming and the results are troubling: otherwise thoughtful design proposals populated with commercial products that are inappropriate and inconsistent. More and more building product suppliers also make their products available online, and Revit now includes an embedded internet search feature to expedite this process.

As a compromise, students are encouraged to use neutral elements that lack articulation and are therefore less objectionable than double hung windows or six panel doors, connoting traditional homes. Almost

unintentionally, these placeholder elements allude to the worst examples of the International style or at best provide a bland and inoffensive version of modernism. Architect and author Vittorio Gregotti warns against this kind of convenience, saying, "It is false to think that culture of industry or building (by now distant cultures from design) could solve the problem of detailing; this might be convenient or economic to the architect, but lead to unprecedented downfall of architecture."<sup>13</sup>

Aalto clearly had similar concerns, having "experimented with and quickly abandoned most of the elements of the International Style Modernist vision – standardization, geometric forms, mechanistic finishes, and the doctrine of material efficiency."<sup>14</sup> This "definitive break from the International Style"<sup>15</sup> coincided with Villa Mairea's completion in 1939. Aalto's thoughtful and intense focus on the elements of architecture provides a critical example of details designed and constructed in a modern but entirely pre-digital era. Edward Ford confirms Aalto's unique status in this regard, recognizing that "at the level of detail Aalto was the great humanizer, the enemy of rigid and arbitrary standards, responding with sensitivity to the minutest of functional concerns, softening the harshness of industrialization."<sup>16</sup> Studying Aalto's work quickly reveals the intense attention paid in the design and construction process to architectural elements such as columns, windows, stairs, handrails, and door handles, among many others. By doing so, Aalto also helps ensure these elements remain in the domain of the architect rather than surrendering them to standardization.

Perhaps the best example of this approach is the Villa Mairea, widely considered to be one of the most important syntheses of "the industrial, the natural, and the vernacular"<sup>17</sup> especially at the level of elements and details. Mairea therefore provides an ongoing reminder of the capacity of details to impart meaning and to express the life of the individual, validating architect Erik Gunnar Asplund's warning that "mass production without the expression of the individual life is dangerous."<sup>18</sup>

Architecture students are rarely afforded the opportunity to design the elements Aalto focused on with such care: door handles, handrails, stairs, and columns, to name a few. To challenge this trend, a professional elective course was created for undergraduate students. The course posits that faithfully recreating architectural elements that were designed and constructed in the modern era before the use of computers would expose deficiencies in both student skill and in the standardized elements and the content creation tools provided in BIM. Effectively, the complexity of the details under

consideration forces students to dramatically develop their ability to design and create custom details digitally. Villa Mairea's unique identity as a canonical work of modern architecture and humane detailing provides an intense and ongoing challenge to these trends.

To thoroughly establish the context for understanding the details of Villa Mairea, a series of lectures was offered at the beginning of the course by Peter MacKeith, the Dean of the Fay Jones School of Architecture and Design. These lectures established the context of Nordic architecture in the late 1930's, surveyed Aalto's entire body of work, and focused on Villa Mairea specifically. Armed with this knowledge, students gathered documentation and developed a coordinated set of measured line drawings from which to model the major elements of the house and site.

All twelve students collaborated to create a Revit 'central file,' rather than subdividing the project and working independently. Working with central files is far more common in professional practice for architects and caused the course to function much more like an architecture firm. Lectures were provided on the technical issues and best practices associated with working collaboratively and developing sophisticated custom content by William Burks. As the Information Technology Director and Project Manager at the acclaimed design practice of Marlon Blackwell Architects, Burks brought a professional perspective given his training and experience as an architect and a contributor to the development of Revit.

Using measured drawings as guides, the digital model of the house took shape with students dividing the various major aspects of the house for development. In this sense, the construction of the digital model illustrates the traditional method of construction: translating two-dimensional drawings into a three-dimensional construct. The digital model was constructed in more or less the same sequence as the actual house would have been, beginning with establishing the topography, setting the foundation, and working up from the basement walls. This process took approximately six weeks of consistent work for the house to be fully enclosed. Building the house in progressive layers of detail served to progressively build up the proficiency necessary for modeling complex details.

At this point, finer architectural elements were distributed for development, beginning with relatively straightforward items such as windows and doors. These elements were often installed in the model using stock



versions from the software libraries as placeholders with the understanding that they would be subsequently modified to match Aalto's designs. This process often demanded the creation of significant new content, or what Revit calls 'families'; collections of similar items tracked through embedded information about their identity and properties. As the level of detail gradually progressed to the most complex aspects and smallest scales at Villa Mairea, every effort was made to initially use the tools included in the software ostensibly designed for such elements.

For instance, the iconic main stair was first attempted by simply using the stair tools. Not surprisingly, and much like the actual construction of the real staircase, the complexity involved demanded an innovative combination of tools and techniques available. This process was incredibly important. By attempting to replicate the wondrous and idiosyncratic details of Villa Mairea, students almost unwittingly plunged deep into the libraries and related menus that inform and define the elements in question. This process inherently developed their knowledge base and skill set, but also established the internal limitations of the software itself and encourages creative adaptation of other tools.

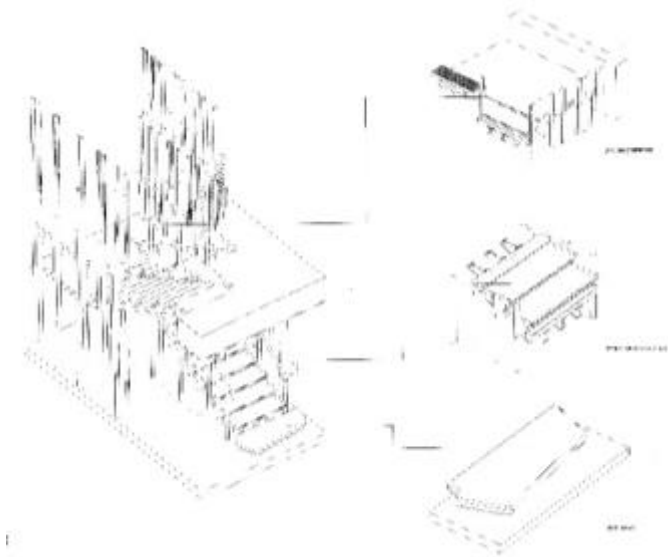


Figure 3 Main stair components

The main staircase required deviation from the standard stair tools in Revit from a team of three students working in concert: one on the carriage structure and columns, one exclusively on the treads and landings, and one on the handrails and mounting hardware. These three students sat together and worked in intense collaboration over a period of three weeks to model the staircase in intense detail, taking great pride in the accuracy of their modeling and in their efforts to translate the Finnish

captions in the original construction drawings. The results were impressive: a highly detailed digital version of the Villa Mairea stair, composed entirely of geometrically flexible components laden with information about their dimensions, materiality and location in space.

The stair in particular illustrates the critical interrelationship of the first two points made in the abstract: that architectural software should (1) automate menial and repetitive tasks, and (2) make difficult tasks easier. BIM software effectively suggests that designing stairs is more like the former than the latter, seeing stairs and rails as a highly repetitive and mathematically predictable assembly therefore prone to automation. The main stair of Villa Mairea, while obeying most rules governing good stair design has an eclectic approach that BIM is incapable of addressing *inside* the dedicated stair tools. By seeing the design of stairs as a difficult task that should be made easier, one could envision an entirely different set of dedicated stair tools.

For instance, Revit offers the capacity to design individual treads, thus ruling out the inclusion of the figured initial tread. Similarly, the stair tools do not allow for repetitive stair treads to be designed independently as constituent families then loaded into the stair design. This approach would effectively hybridize the parametric approach to stair design (the menial and repetitive portion) with the power of custom family creation (the difficult task portion.) Each tread could simply be assigned a type and then governed by the calculations that currently control the distribution of treads and risers. This approach could also be used for the design and articulation of the landing which currently offers no significant controls beyond depth.

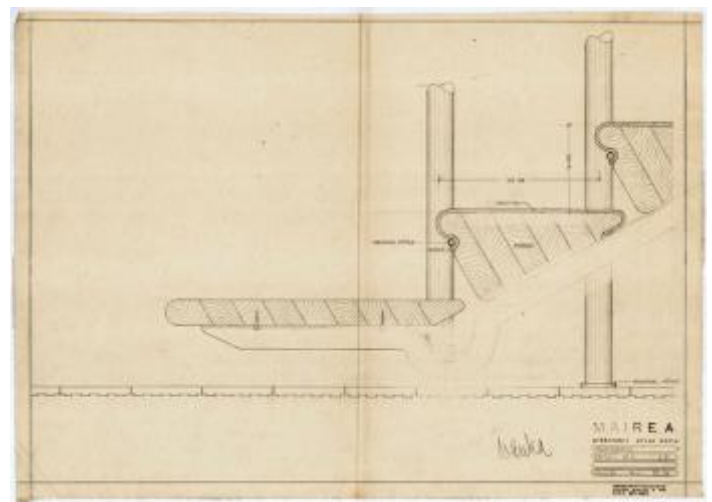


Figure 4 Stair construction drawing,  
[http://www.alvaraalto.fi/net/villa\\_mairea/en/](http://www.alvaraalto.fi/net/villa_mairea/en/)

The stair structure or carriage has similar limitations and is considered strictly as extrusions along a path generated by the calculations defined by the stair type in Revit. In the case of the Villa Mairea stair, the terminus of the carriage is customized and articulated to respond to the figured base. A similar approach could be useful for the design of handrails, seeing them as a combination of elements rather than as a strict extrusion of a single profile. By offering these options for customizing the articulation of the stair treads and structure, the act of designing stairs is facilitated by the software, making a difficult task easier, rather than being dismissed as a menial task to be automated and therefore lost as a design opportunity.

The customized columns that flank the main stair were modeled along with each of the varying types in Villa Mairea. For each instance, students began with a standardized column type that was available in the software libraries as a placeholder, either steel or concrete. Each standard column was then systematically replaced by a custom Revit family constructed from existing drawings and images. As a result, a complete and accurate taxonomy of column types at Villa Mairea was created.

Similar attention was given to the entry sequence which uses several column types. The process of modeling the various components including the wooden screen, stone steps, skylights, and custom front door, was divided among several students who worked in close collaboration.

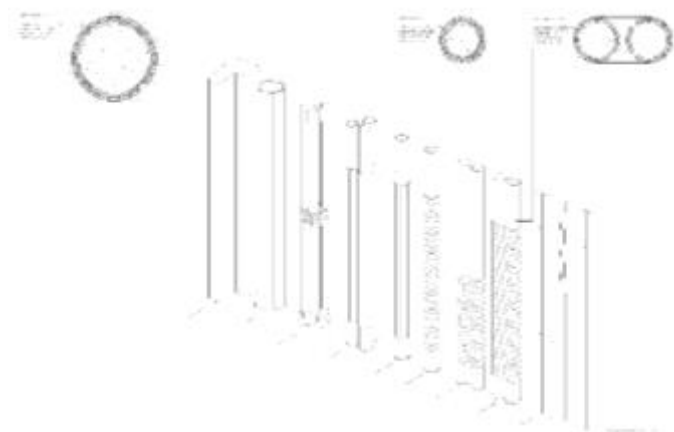


Figure 5 Column taxonomy

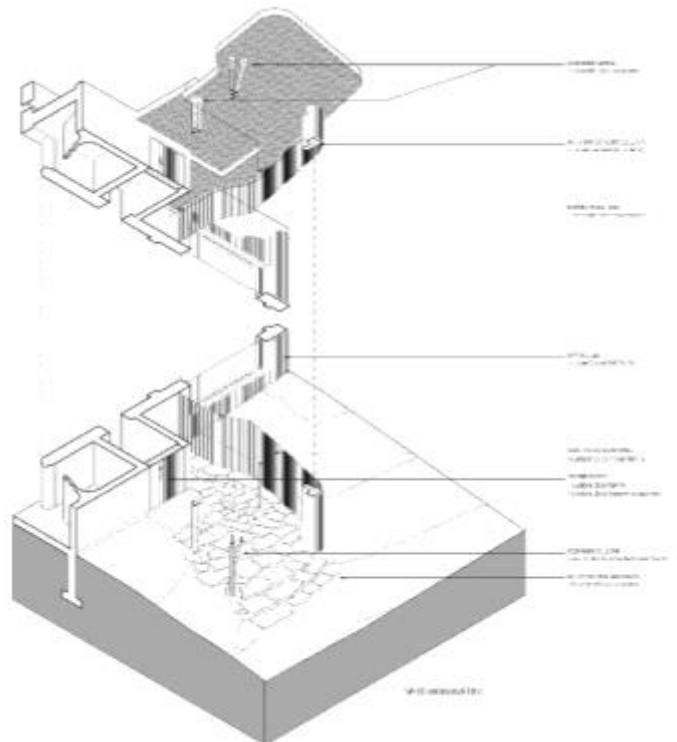


Figure 6 Entry sequence axonometric plan and ceiling plan

Other areas of focus included the distinct angled window boxes on the second floor, the studio, and the outdoor fireplace and terrace leading to the sauna. Even the iconic pool was built in detail. One student worked exclusively in the library for four weeks, creating custom Revit families for the bookshelves, the scalloped wood and glass enclosure between the bookshelves and the ceiling, and even the door handle Aalto designed for the library.

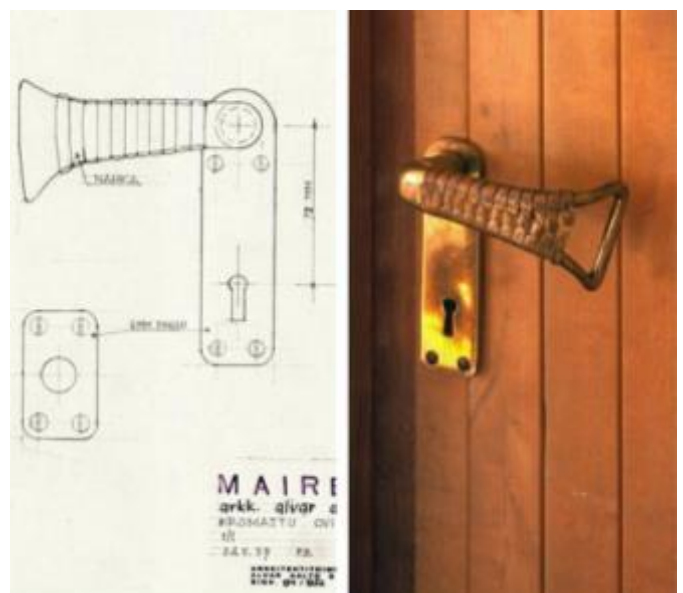


Figure 7 Library door handle detail, Retrieved April 27, 2017, from [http://www.alvaraalto.fi/net/villa\\_mairea/en/41.htm](http://www.alvaraalto.fi/net/villa_mairea/en/41.htm)



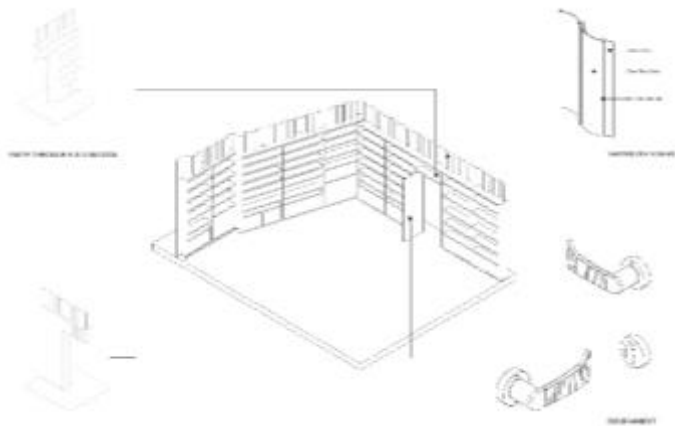


Figure 8 Library shelves, screen, door and handle

Instead of simply translating the drawings and images of Villa Mairea's construction assemblies into rigid geometric copies, most of the student work was in fact an act of adaptation that transforms a simpler version of elements provided in the software library into a complex hybrid, much like the process Aalto used but completed digitally instead of manually. The taxonomy of columns is perhaps the best example of this approach, beginning with a standardized column and progressively adding the layers of detail Aalto designed in order to humanize and personalize each type.

Throughout the course, students were required to create parametric versions of the details they studied, rather than simple copies. In effect, the parametric versions of details and their constituent components are adaptable because they are controlled by information beyond their just their basic dimensions. This has the benefit of portability: students realize the components they make can be used other projects rather than returning to the library of stock components. Perhaps even more importantly, by studying how Aalto transformed basic architectural elements into personalized and intensely imaginative works, students begin to understand the creative process as one of adaptation rather than purely creative inspiration. Drama critic and author James McKinnon describes this important difference, saying "In contrast to the habitual association of adaptation with "copying" and plagiarism, adaptation suggests that learning to copy is actually an effective way to develop creative skills and foster critical engagement simultaneously."<sup>19</sup>

Students came to understand Aalto's process of creative adaption both at the conceptual level of the plan where the L-shaped configuration is drawn from Finnish vernacular farm houses or at the level of detail where simple steel columns are bundled and wrapped with

rattan. As McKinnon describes, "Adaptation-centered pedagogy offers many strategies for challenging false dichotomies and putting both creative and critical talent within the reach of any student. For one thing, studying adaptation reveals and demystifies the process of artistic creation."<sup>20</sup>

Aalto is clearly not inventing the L-shaped plan or the column, but transforming them and embedding them with a humanistic interpretation of modernism. Progressively reconstructing Villa Mairea and its details "demystifies "originality" by showing students that masterpieces are not suddenly invented out of nothing, but through skills and methods that they too can master."<sup>21</sup> Students also discovered areas of missing detail since they did not have a full set of construction documents available. Consequently, students had to speculate about connections in various assemblies, shifting the process from documentation towards design development.



Figure 9 Exterior perspective of digital model

As a conclusion to the course, each student created two presentation boards related to their primary area of focus in Villa Mairea, one of which chronicled the drawings and photographs they used to inform their work, and another to illustrate the work itself. The latter board required the isolation of the details or assemblies with the various 'families' and constituent profiles identified in order to illustrate all of the various pieces the students made to duplicate the original. These drawings were essentially exploded axonometric drawings, but they deconstructed the digital development process rather than the physical construction process. Coupled with the presentations were 3D printed fragments that further illustrated the level of detail embedded in the digital models. The presentation boards and printed models were exhibited together to illustrate the scope of the course and the depth of detail the students achieved.



*Figure 10 Exterior perspective of digital model*

Unfortunately, the process of selecting pre-existing components in BIM will only become easier and more commonplace unless students are taught to resist this trend. Aalto's extraordinary response to industrialization and critical position on the "overemphasized quantifiable aspects of economy and efficiency,"<sup>22</sup> ensures his ongoing relevance in teaching architecture students to challenge the libraries included in their software by mastering digital tools. Perhaps no architect enjoys a greater distance from the troubling tendencies this course confronted than Alvar Aalto, and no project exemplifies the challenge to thoughtless designation more than Villa Mairea.

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