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T3 Modelling

3.3 Physical Modelling

**Essential Idea:**
A physical model is a three-dimensional, tangible representation of a design or system.

**Concepts and principles:**
- Scale models
- Aesthetic models
- Mock-ups
- Prototypes
- Instrumented models

**Essential Understanding:**
- Applications of physical models
- Use of instrumented models to measure the level of a product’s performance and facilitate ongoing formative evaluation and testing
- Advantages and disadvantages of using physical models

**You as a designer:**
Designers use physical models to visualize information about the context that the model represents. It is very common for physical models of large objects to be scaled down and smaller objects scaled up for ease of visualization. The primary goal of physical modelling is to test aspects of a product against user requirements. Thorough testing at the design development stage ensures that an appropriate product is developed.

Physical modelling not only allows designers to explore and test their ideas, but to also present them to others. Engaging clients, focus groups and experts to interact with physical models of products allows designers to gain valuable feedback that enable them to improve the design and product-user interface.
Applications of Physical Models
Physical models allow visualization, from examining the model, of information about the object that the model represents. A physical model can be used to obtain important data such as test and simulation measurements. Modelling, using physical models allows the user to better understand the problem and presents a means for manipulating the object in order to analysis the results of various tests or other changing situations.

Scale models
A scale model is a smaller or larger physical copy of an object. Scale models allow visualization, from examining the model, of information about what the model represents. A good example of scale models is seen in architecture, whereby a full-size building is modelled at a greatly reduced scale. This enables designers to visualize the structure of the building, but also the exterior and interior aesthetics and lines.

Unforeseen factors can be highlighted in the actual environment in which the product/system will be utilized. The purpose of a smaller scale model may be to have a better overview, for testing purposes.

The purpose of a larger scale model may be to see the structure of things that are normally too small to see properly or to see at all, for example, a model of an insect or of a molecule.

Scale modelling can be a fast method to ideate or something more sophisticated to communicate design thinking, ideas and aesthetic issues.
Jean-Paul Viollet tells the story behind Atelier Viollet’s scale model furniture:

“The idea behind fabricating the scale models of furniture came about when I was working with a very busy client. I was only allowed a few minutes of their time to present my concept of design for a commission. Instead of presenting them with a drawing I felt that a scale model, made with the exact materials and finishes, would more quickly convey how the finished piece of furniture could look. This process was of course time consuming, but I also found it very rewarding. I have since made a few models for various clients and they now form a small collection in my office.”

Aesthetic models

Aesthetic models are developed to look and feel like the final product and the models are models look realistic to the product they are trying to represent. They are used for many purposes including ergonomic testing and evaluating visual appeal. Aesthetic models look like but do not work like the final product. Aesthetic models can be relatively simple, consisting of solid chunks of foam finished and painted to look like the real thing, or they can be more sophisticated, simulating weight, balance and material properties.

Usually, aesthetic models are “for show” and are not designed to be handled excessively. They give non-designers a good representation of the feel and look of an object. For example, production engineers can take data to assess feasibility for matching manufacturing systems. Aesthetic models are expensive to produce, as they need to have a good surface finish and be life-sized. They are sometimes called ‘look-like models’.
Mock-ups

Mock-ups are used to test ideas. They are scale or full-size representation of a product used to gain feedback from users. A mock-up can be considered a prototype if it includes some functionality.

Mock-ups are commonly used by product designers, architects, and engineers. The intention is often to produce a full-sized replica, using inexpensive materials in order to verify a design.

Mock-ups are often used to determine the proportions of the piece, relating to various dimensions of the object itself, or to fit the piece into a specific space or room. The ability to see how the design of the piece relates to the rest of the space is also an important factor in determining size and design.

When designing a functional product, such as a household device, mock-ups can be used to test whether they suit typical human shapes and sizes. Designs that fail to consider these issues may not be practical to use. Mock-ups can also be used to test colour, finish, and design details which cannot be visualized from the initial drawings and sketches. Mock-ups used for this purpose can be on a reduced scale.

The cost of making mock-ups is often more than repaid by the savings made by avoiding going into production with a design which needs improvement.
Prototype
A prototype is a sample or model built to test a concept or process, or to act as an object to be replicated or learned from. A prototype is used to test and validate ideas and can be used throughout design development. Prototyping can be used to provide specifications for a real, working product rather than a theoretical one. Prototypes are developed to work from two perspectives: the point of view of the development team, who can learn by creating the product, and the point of view of the user, from whom the development team can learn through user interaction and feedback. A prototype can be developed at different fidelities within a range of user and environment contexts.

Fidelity range
In the fields of modelling and simulation, fidelity refers to the degree to which a model or simulation reproduces the state and behaviour of a real world object, feature or condition. Fidelity is a measure of the realism of a model or simulation. Simulation fidelity has also been described in the past as "degree of similarity".

The range of fidelity is:

<table>
<thead>
<tr>
<th>Range of fidelity</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Model</td>
<td>conceptual representation analogous (comparable in certain respects) to the idea</td>
<td>representation of aspects of the idea</td>
<td>mock-up of the idea, as close as possible to the final product</td>
</tr>
</tbody>
</table>

Low fidelity. Click on the image to watch a video showing an example of low fidelity
**Middle fidelity**—representation of aspects of the idea

**High fidelity**—mock-up of the idea, as close as possible to the final product. Click on the image to see a very cool prototype.

**Modelling at Dyson**
Context Ranges
The range of contexts is:

- **Restricted**—in a controlled environment
- **General**—any user, any environment
- **Partial**—final user or environment
- **Total**—final user and environment

A combination of fidelity and context provides validation of an idea and/or further insight for development.

Instrumented physical models
Use of instrumented models to measure the level of a product’s performance and facilitate ongoing formative evaluation and testing. Instrumented physical models are equipped with the ability to take measurements to provide accurate quantitative feedback for analysis. They can be used effectively to investigate many phenomena such as fluid flows in hydraulic systems or within wind tunnels, stress within structures and user interaction with a product. For example, an instrumented model of a keyboard can record the actions of the user and provide data on how often keys are used and the number of errors a user makes (that is, the number of times the backspace or delete key is used). These models can be scaled in terms of both geometry and important forces. Watch the video clips

Applications of physical models
- Product design
- Architecture and Engineering
- Medical research
- Automotive industry
Task
Before scrolling down, make a list of the advantages and disadvantages of using physical models

Advantages and disadvantages of using physical models

Advantages

• Explore and test ideas
• Easily understandable
• Communication with clients
• Communication with team members
• Ability to manipulate ideas better than with drawings

Disadvantages

• Designers can easily make assumptions about how accurately a model represents reality
• It may not work like the final product
• Might not be made of the same material
• Time consuming to make.
• Can be costly (prototypes).
<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumers can see the shape, proportions and colour of the product easily e.g. car at a car show</td>
<td>Time consuming to produce</td>
</tr>
<tr>
<td>Real visual image</td>
<td>High level of skill to produce them</td>
</tr>
<tr>
<td>Easily understood by a non-technical audience</td>
<td>Need resources – machinery and equipment</td>
</tr>
<tr>
<td>Can handle physical models which is good for user trials/market research when considering ergonomic aspects of a design can be assessed e.g. clay models</td>
<td>Consumption of raw materials, energy, and disposal is not very good for the environment</td>
</tr>
<tr>
<td>Used to communicate with different audiences, consumers who are not technically minded and professionals e.g. manufacturers.</td>
<td>Good physical models are expensive to produce</td>
</tr>
<tr>
<td>With prototypes can consider design considerations before going to production which means the green aspect of the product could be improved (physically testing it)</td>
<td>Not very flexible when they are made</td>
</tr>
<tr>
<td></td>
<td>Scale models can generate unwanted errors through scaling e.g. a bridge, tests could be incorrect</td>
</tr>
</tbody>
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