PRO 204 – Modeling Prototyping

PROTOTYPING INTERACTIVE ELECTRONIC PRODUCTS

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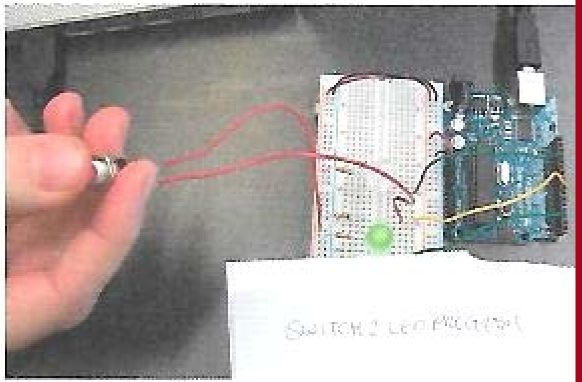
Electronics are ubiquitous and are found in a variety of products, including consumer electronics, medical systems, toys and even soft goods (textile products). Products therefore increasingly incorporate a growing list of interactive technologies, including: screen-based interfaces, keypads, wireless elements and sensors.

In the previous chapter it was shown how interactive elements could be tested initially with simple low-fidelity prototypes by investigating scenarios. Screen-based interfaces can, for example, be acted out step by step with a paper prototype. This can then progress into higher-fidelity prototypes on screen using programs such as Powerpoint® or Flash®. Beyond screen-based interfaces, it may be important to have the prototypes work so that instead of scenarios being acted out, they can actually be experienced through real sensors and output. New simple toolkits to explore interactive product ideas in the form of works-like prototypes have become increasingly popular and accessible. What is particularly attractive is that they do not require an extensive knowledge of electronic design. These tools are used as a proof of concept to make sure the ideas are viable and to investigate the benefit for the end user. The focus here is not on electronics design, but on prototyping the experience. Design students have several toolkits at their disposal. Lego Mindstorms® is a robotic kit from Lego® with a number of sensors that can be used to detect sound, motion and range, which in turn can be translated into specific outputs such as motion and light.

More elaborate prototyping platforms have also become available that specifically target the artist and designer. Arduino is an open-source electronics prototyping platform that can be used to create interactive products. Software can be downloaded from the open-source site www.arduino.cc, along with instructions on where to purchase the boards. The Arduino board also uses sensors and is able to drive outputs. The small and inexpensive boards can also be incorporated more easily into working prototypes than the bulkier Lego® system.

Lego Mindstorms® NXT is a stand-alone controller with an easily programmable interface. A variety of sensors, including touch, infrared, range and sound, can be used to produce output including servomotors. It is programmed through a computer.



The Smart Rollator project at Carleton University, Ottawa, used Lego Mindstorms® and a range of prototyping platforms such as Arduino open-source software

Case Study Kurio Interactive Museum Guide

Kurio is an interactive museum guide system designed for small groups visiting the museum. It is comprised of four hand-held devices, a tabletop display and a Personal Digital Assistant (PDA), all networked wirelessly to a central reasoning engine that guides the family through the museum visit.

The Kurio interactive museum guide system is the outcome of a collaborative research project between Simon Fraser University, Surrey, British Columbia and Carleton University, Ottawa, Ontario. The case study highlights how low-fidelity prototypes and more complex high-fidelity working electronic prototypes may be used in the same project. The objective was to use technology to enhance interaction among family members in the museum setting. Existing museum guides typically use audio or a Personal Digital Assistant (PDA) to guide the visitor through a museum setting. The problem is that this tends to isolate family members from one another and thus detracts from social interaction

Kurio is a museum guide system designed to enhance interaction among family members and small groups visiting the museum. The Kurio system allows visitors to choose from a range of interactive scenarios – in one scenario a family imagines themselves as time travelers whose time map is broken and so they are lost in the present time. In order to repair the time map, family members complete missions comprised of a series of challenges to collect information from the museum helping to reconstruct the map. The interactive museum guide itself is comprised of four tangible devices, a tabletop display, and a personal digital assistant (PDA) all networked wirelessly to a central reasoning engine that guides the family through the museum visit.

The Kurio system is very different. It uses a set of four different wireless hand-held devices to create a socially interactive game where family members collaborate in collecting different types of information in a museum setting. The four collecting devices are easy to operate and simply have one button. They include a pointer (for pointing to an artefact), a listener (for collecting sounds), a finder for guiding users around the museum and a reader (for capturing text). These devices are coordinated through a PDA screen-based device that is operated by a parent.

The system was not envisioned like this at the beginning of the project, which took about three years to complete. It emerged as a result of observing and studying families interact in real and simulated museum settings. The process was made possible through prototyping that

models also showed that the children had a preference for larger and brightly coloured devices. The final working prototypes made use of prototyping electronic kits and 3D printed parts. These included a variety of sensors as well as wireless technology, all available in prototyping kit formats. The final museum field trial was a proof of concept that illustrated the benefits of interactive play to create a more interactive and social learning experience in a museum setting amilies.

Explorative prototypes were made in foamboard and Styrofoam to allow team members to develop interaction scenarios that could be studied further.

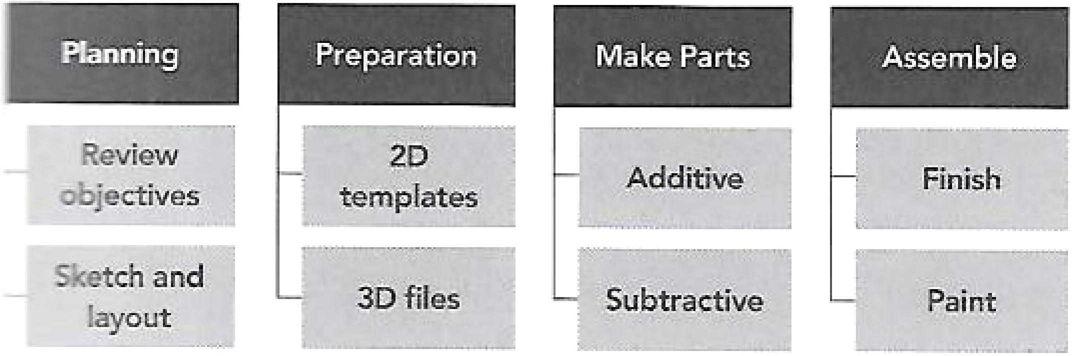
WORKFLOW

Workflow is a systematic step-by-step process of creation. It applies to any skill, including sketching as well as modelmaking. It needs to be learnt, but with time becomes a natural process. Developing a good sense of workflow is perhaps the most critical aspect of improving your modelmaking skills. The experienced sketcher knows how to draw a perspective view of an idea with little effort. Similarly, the experienced musician is able to play the instrument as an extension of his or her own body. Prototyping is a similar type of skill, where practice will make it more natural and effective to go and build to explore, test, communicate and verify your designs. You will develop a sense of method and materials through practice. There is no formulaic or correct way of doing something, except for safety matters. This book serves as a foundation upon which new knowledge and experience can be built. There are many different modelmaking techniques and approaches, and you will learn new tips and tricks along the way.

When a piece of self-assembly furniture is purchased from a company such as IKEA, someone has already figured out the assembly workflow. The instruction manual guides the customer through the process of putting it all together and some tools are required. The aspiring designer needs to learn both how to make things and how to instruct other people to put them together. Modelmaking is a great way to become more familiar with materials, construction and assembly.

Basic Modelmaking Workflow

As a starting point consider the following basic approach to workflow:



Planning

The starting point for the model is usually a sketch or a simple computer drawing. The first step is to analyze the prototyping and modelmaking objectives, which involves two separate tasks. The first is to review what materials and processes are suitable by thinking through principles and choices (see Chapter 4, page 43). In early models this is typically a single material, while for more advanced prototypes several materials and processes tend to be combined.

The second task is to plan what pieces need to be made and how. For simpler, exploratory models this is a simpler and looser process. In essence the model, rather than the product, is being designed at this point. The model itself will be sketchy and much is worked out on the fly. For more advanced and higher-fidelity prototypes the drawings need to be more accurate and detailed in the form of a layout. This establishes the overall form and proportions as well as making sure that internal components fit. These prototypes should be drawn to scale in either

Konstantin Grcic reverse-engineered the first Myto chair prototype as a starting point for CAD.

manner using screws and other hardware. In this case the exposed fastener may not look good, but that is probably of no consequence as it is only a works-like prototype. For looks-like prototypes it may be simpler and easier to glue parts together, even if that is not how they would be held together in production.

Reverse-Engineer Workflow

Complex sculptural forms often need to be developed by hand in such materials as clay or foam. Typical products that are modelled sculpturally include cars, helmets and character toys. The model then serves as a blueprint for the final form, which must be digitized in order to be brought into CAD.

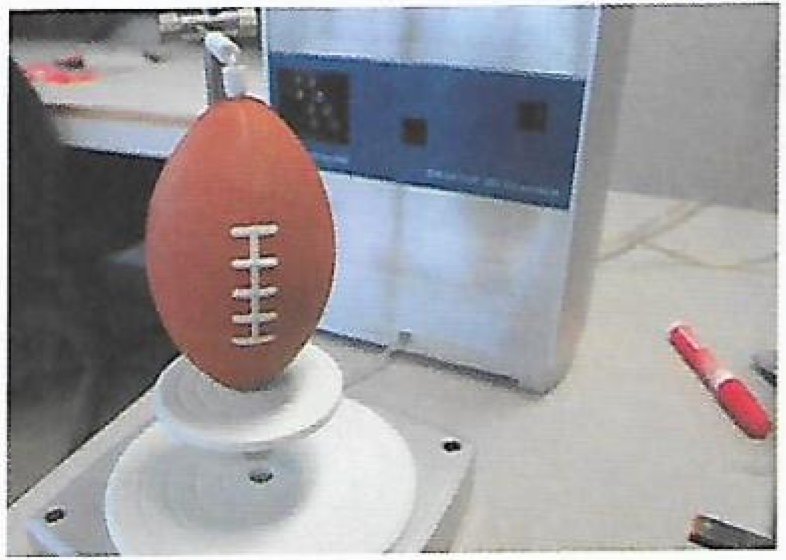
Pictures and Measurements

A basic way of reverse-engineering a product is with a digital camera and some manual measurements. The workflow would be:

Take pictures and measurements → Import pictures to 3D program → Construct 3D geometry

Pictures can be scaled and brought into a 3D CAD program, where they serve as guides for the digital modelling. Some useful tips:

— Take pictures from side, top and front elevations and bring them into the computer system aligned on to these planes. This will form a good starting point for the model.
— Do not use a wide angle, and be careful of foreshortening. A picture taken further away will have less distortion. Align the camera to have a dead-on view.
— Include a ruler in the picture as a quick scale reference.



The NextEngine stationary desktop scanner includes a rotating mounting base that automatically rotates the object to be scanned.

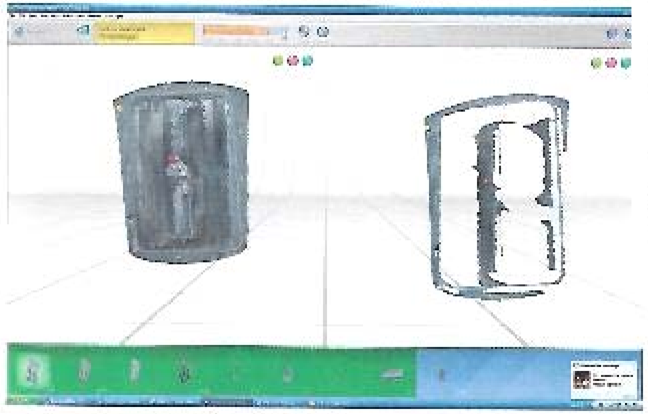
Measurements are typically made with a vernier caliper (see Chapter 8, page 58). It may be necessary to mark up the model in order to create reference points that can be traced back to the pictures. Consider using drafting tape as it is low-stick, marks well and can be removed afterward. As cross sections are created it is advisable to print them out on a piece of paper and cut out the profile to see if it fits on the model. This serves as an excellent guide.

Laser Scanning

Laser scanners are either hand-held or stationary. The hand-held scanners are suitable for scanning large surfaces, such as car bodies. A scanner can scan only what it sees. This means that either the operator needs to move around the object during the scanning process or else the object needs to move relative to the scanner. Hand-held scanners follow the first principle, whereas stationary scanners need to combine several scans from different views.

Raw data such as point clouds can be very difficult to work with, which is why manufacturers tend to provide software that simplifies, and to a large extent automates, the work. The quality of the software provided with the scanner is important, as the process can be largely automated with good software. In order to align different scans and data, the scanned object is often fitted with circular scanning points that help the software triangulate patches.

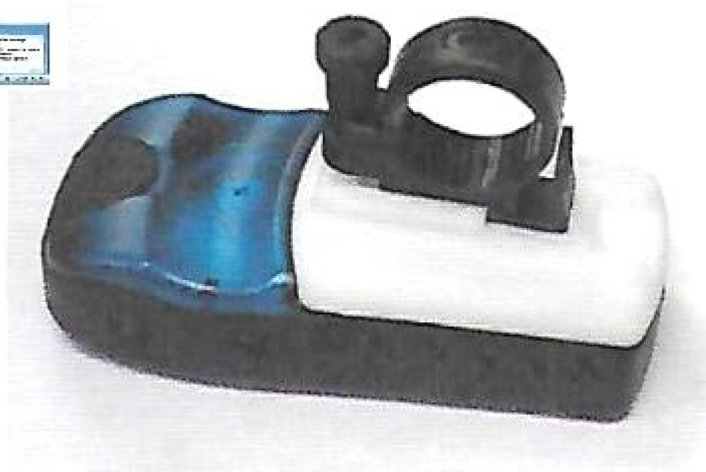
Chapter 16 on modelling clay shows how hand-held scanning was an important aspect of creating 3D CAD file data for the Olme Spyder (page 140). This data was then in turn used to mill a full-size car model in foam. The workflow was as follows:



Scan 1/4 scale model → Construct new 3D geometry → CNC full-scale model

The new battery door (white) was printed on a Dimension 3D printer, based on data scanned in from the original battery door (black).

Scanning can also be used to make a modification to an existing part. In the following example, the battery door on a portable GPS was scanned in and then exported to a 3D CAD system, where the model was modified to include a mounting bracket for a bicycle handlebar. In order to do this the scanned-in model was first turned into a solid 3D CAD model in the NextEngine ScanStudio™ software. This model was then exported to SolidWorks®, where the extra features were added.



Portable GPS with new battery door containing a clip-on bracket for a bicycle handlebar.

TOOLS

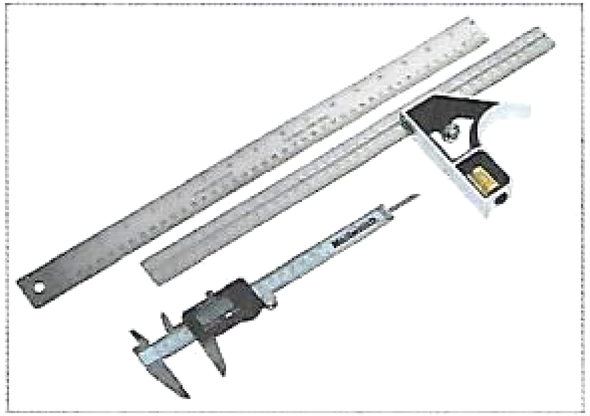
Basic Hand Tools

Safety Check

- Read Chapter 5 on health and safety, pay particular attention to mechanical hazards, personal protective equipment and risk assessment
- Keep all your tools in good condition and use only for their intended purpose
- Store tools and materials away from children

Basic Toolset

It does not take an abundance of tools to start making models. A basic toolset will allow you to produce low-fidelity models in a variety of materials including paper, cardboard, foamboard and various types of foam. As shown in the Prototyping section of this book, these low-fidelity models precede the higher-fidelity models and are a big part of the design process. The basic toolkit includes simple hand tools, glues, fillers and personal protection equipment. It is a wise investment to start building this toolkit while in school, as it will serve you as a practising designer for years to come. Keep your tools in a suitable toolbox.



Steel rule (top), steel square with adjustable base (middle), electronic vernier caliper (bottom).

A good toolbox is essential for safely organizing and storing your personal tools. It typically contains items including: safety glasses, glue, filler, knives, measuring tools, small hobby saws, rasps, rotary tool and pliers.

Layout and Measurement

Good workmanship starts with accuracy of measurement. The use of appropriate measuring tools is crucial to obtaining reasonable results. There are three basic measurement tools that need to form part of any designer's toolkit: a steel rule, a vernier caliper and a steel square.

The steel rule is used to mark straight lines or to guide cuts with a Stanley knife or scalpel. The steel rule can be used to measure overall dimensions to an accuracy of half a millimetre at best, which is why a set of electronic vernier calipers are used for dimensional accuracy instead. The caliper measures thickness, depth and width to an accuracy of one hundredth (0.01) of a millimetre (0.0004in). Steel squares are used to mark a perpendicular line to an edge of material. They are also used to create a vertical line when standing on the adjustable base.

Safety Check

- Read Chapter 5 on health and safety, pay particular attention to mechanical hazards, personal protective equipment and risk assessment
- Keep all your tools in good condition and use only for their intended purpose
- Store tools and materials away from children

Workshop tools can loosely be categorized into three categories. Hand-held power tools are quite common and are sold for professional as well as home use. Stationary power tools include hobbyist varieties. The last category consists of larger industrial machine tools. Never operate any power or machine tool without obtaining professional training and supervision. The following description of various power tools is simply an overview of what they are used for and should in no way be interpreted as a substitute for proper training and education in the use of these tools. As a general safety preparation:

- Always wear safety glasses when using power tools
- Tie back long hair and remove loose clothing and jewellery that could become caught in the machine
- Wear proper footwear

Hand-Held Power Tools

A rotary hobby tool is a versatile modelmaking tool. It is supplied with a number of tool bits for cutting and grinding, as well as sanding. They are a useful addition to most basic toolkits, given their small size and versatility. Dremel is a popular brand of these tools.

Larger hand-held power tools include a cordless drill, a circular saw for cutting sheet materials and a jigsaw for cutting more complex outlines in sheet materials. Cordless versions now exist of many of these types of tools, adding even more mobility and flexibility.

Stationary Power Tools

Drill Press

The drill press (or pillar drill) is more accurate than a hand-held power drill and will provide more guidance and control during the drilling operation. Drill presses can also be used with circular saws, drum sanders and countersinks. The drill press is either floor or bench mounted and has an adjustable table that can be lowered or raised depending on the size of the workpiece. The drill bits are mounted in a chuck that turns via a motor. The speed can be changed through a pulley arrangement on top of the machine, which should only be adjusted when the machine has stopped and is unplugged.

Different materials require different cutting speeds. Steel, for example, needs to be cut at a slower speed than aluminium and also requires that cutting oil be used. A smaller diameter tool also requires a higher speed than a large diameter tool, since the velocity at the tool perimeter is lower. Refer to a drill speed chart for recommended speeds.

Table-mounted and floor-standing drill presses.

Drill press speed can be adjusted through a pulley arrangement between the motor and spindle. This should only be done when the machine is stopped and unplugged. The chart on the bottom of the guard cover on this machine shows speed options.

Rotary tools, such as this one made by Dremel, include a wide array of small bits suited to modelmaking work.

Hand-held drill, circular saw and jigsaw.

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