Engaged Collaborative Ideation supported through Material Catalysation

Leaders, researchers, engineers, designers, users and investors have diverging norms, thought patterns, languages and foci for creativity [5]. In play with shared toys children manage to overcome basic differences and create shared visions. Could similar engagement support collaborating grownups in creating breakthrough products? Through studies of design behaviour, cognitive psychology, neurobiology and phenomenology I have in my doctoral thesis [6] concluded that if design actors are allowed to play with their ideas in shared reality, this can be achieved. The condition for efficiency of such a process is that 'toy' physicality can represent emerging ideas so quickly and cheaply that they can become 'catalysing' parts of the game. For the first time in history such an approach is now possible through employment of Rapid Prototyping (RP) technology. Research on such interaction between mental and physical representation is summarily presented in this paper – from theoretical and empirical viewpoints. For some readers an access through the case studies first may be preferential.

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Reconciling views on consciousness and conceptualisation.

Design conceptualisation can be defined as creating an idea, gradually maturing its meaning and eventually expressing the understanding through representations like words, drawings or models. Unlike traditional idea-to-product approaches to innovation, the *Innovative Cross-professional Interaction* (ICI) process focuses generation of conceptual ideas in dynamic patterns alternating between physical experience and mental representation and processing. How is a generative interaction between physicality and mentality to be understood? This question is not unproblematic as it may imply partly opposed positions on human consciousness (what is an idea?). Within design oriented fields there is considerable agreement that physical representations or 'tangible interfaces' will support the communication between design actors: Ehn [9]; *hands-on-experience,* Star [22]; *boundary objects,* Perry & Sanderson [21]; *procedural artefacts,* Brandt [2]; *things-to-think-with,* Boujut & Laureillard [1]; *intermediary objects,* Bucciarelli [3]; *linguistic artefacts*. Cognitive psychology has approached human faculties involved in creative conceptualisation, where e.g. Finke, Ward and Smith [10] describe how much of everyday thinking is based on formation and transformation of *visual images* and how pathways of creative exploration are often opportunistic and unforeseeable. Kosslyn [16] has specified four types of processing of mental imagery; *image generation, image inspection, image transformation* and *information retrieval* from long-term memory. And Kavakli & Gero [13] have described how *pattern goodness* may positively affect the rate of perceptual actions in relating to representations. But neurobiology and philosophy may have diverging views on how perception influences ideation. Physicalism battles with understanding how consciousness can be nothing but brain cells. Idealism, where all I can know is my impression, fights the ghost of uncertainty. But an integration of the two appears as impossible since they seem basically opposed.

An understanding of the problematic of 'Cartesian dualism' between mind and world (involving the philosophical subject/object problem) should not be sidestepped in design thinking like most design theorists seem to do. Design experiences involve both affective involvement with material representations and abstracted analysis of the experienced, and both 'modes' must be accounted for. Velmans [25] presents an outline of human consciousness where the proceedings of updated neurobiology are embraced so long as they are not misinterpreted as its ontology; "no discovery that reduces consciousness to brain has yet been made" (p.31). Consciousness is in his view restricted to situations where awareness or phenomenal content is present, and he specifies its three possible foci: space, body and 'inside'. Engaged human experience then is where *conscious awareness* is focused at will, and not in the brain where its physical representation is. But these 'locations' are seen as *two fundamental aspects* of being in the world. They can together account for individual perception – which belongs to the encompassing world totality where all individual views are embedded. This *reflexive monism* framework reconciles phenomenology and neurobiology as two valid and inter-dependable approaches to human action – and can be used for building design theory. The framework involves both sensuous engagement and disengaged 'reason'.

Damasio [8] and Lakoff & Johnson [17] describe the neurobiological view of embodiment of experiences through synaptic brain cell connections. But in creative conceptualisation *breaking old* embodied patterns and *forming new* embodiments become central objectives – to convince us of the superiority of new possibilities. Merleau-Ponty [19] with his *intermonde* concept (between-world) describes a state of being between subject and object where wholeness can be immediately experienced. Ornstein [20] describes such between-world scenarios in analyses of how *deautomatisation* is a central aspect of oriental cultures where movement, dance, play, rituals, music, aesthetics or contemplation/ meditation are examples of intentional breaking of habit to achieve intuitive opening of the mind. Böhme [4] likewise describes how *atmospheres* only can be created between the subjectivity of a perceiving individual and object physicality and how they have high importance for communication through the connection they produce between actors. Immediate perception of atmosphere and wholeness thereby is before separation of *I-pole* and *thing-pole*. Husserl [12] basically describes how my engaged experience of a phenomenon (intentio) and the phenomenon as object of an experience (intentium) must converge repeatedly over time to achieve stable understanding or meaning. All these aspects contribute to my resulting depiction of a humanly foundation for a model of design conceptualisation, which includes between-world relationships.

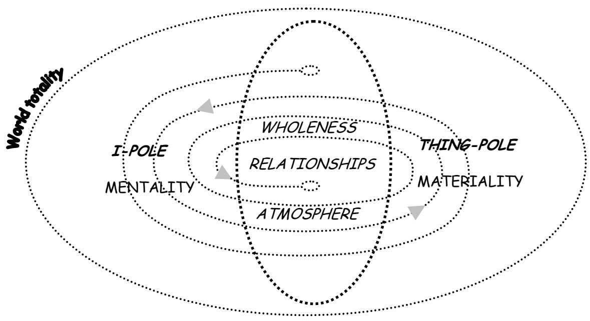


Figure 1: A basic conceptualisation pattern describing conscious awareness flow towards understanding

A PoEM of design action

From fifteen case studies in all of design behaviour supported through RP technology and the above understanding of a conceptualisation process, a metaphorical process model called the *Plant of Emerging Materiality (PoEM)* eventually resulted. The elaboration of this model is reported in [6] and [7] and will only be summarily described in this paper, which is intended to give a simplified access to the framework (at the expense of consistency).

The model was built from a 'design cycle' negotiated between collaborating research actors, untrained in philosophy, and according to a Participatory Action Research regime (PAR). The cycle can be seen as an extension of Figure 1 and was assigned to a *formative mode* of reforming weak RP models through handforming and clay application to improve aesthetics and functionality. This cycle was found to closely resemble The Process of Experiential Learning [15] – if the physical representation was introduced into that model and understood as a *catalyst* of sense-based perception. But the processes could not be identical since ours was understood as depicting sensuous forming action (a 'unification' of mind, body and material) and Kolb's as adaptation and interpretation aspects of form (a 'separation' of mind and material). The solution to this problematic was found by integrating the two models with the physical 'catalyst' as connecting member and calling his model an *adaptive mode.* The dotted line represents the neurobiological and the whole line the phenomenal aspect.

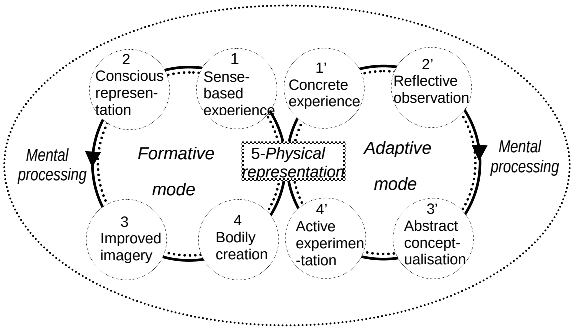


Figure 2: A dual-mode design process showing inter-connection between awareness on forming or adaptation aspects

As the understanding of wholeness experience versus I-pole/thing-pole focus of Figure 1 together with the dynamic convergence towards stable concepts should be part of this regime, the interactive pattern within and between modes can be depicted as converging leminscates[1]. Through empirical research it has been shown how the physical representation can be shared by many actors in a shared context, and therefore represents *a unique opportunity for negotiation* between diverging mentalities. Dislike individual processes of formative and adaptive contributions can be depicted differently.

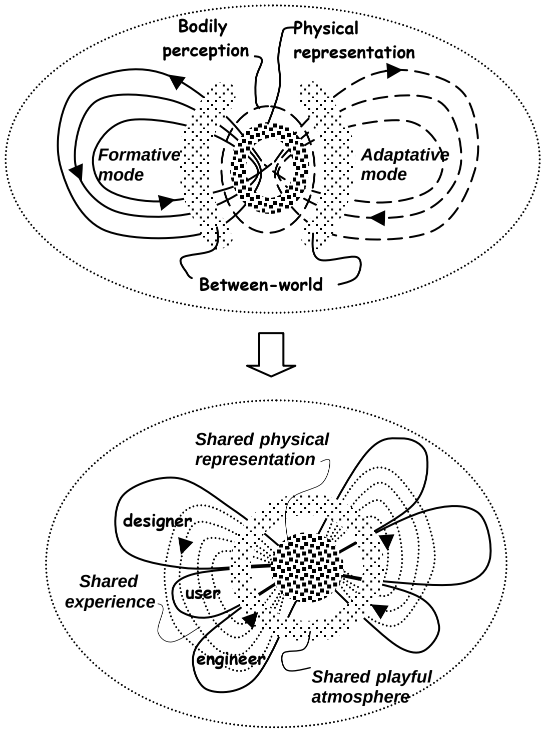


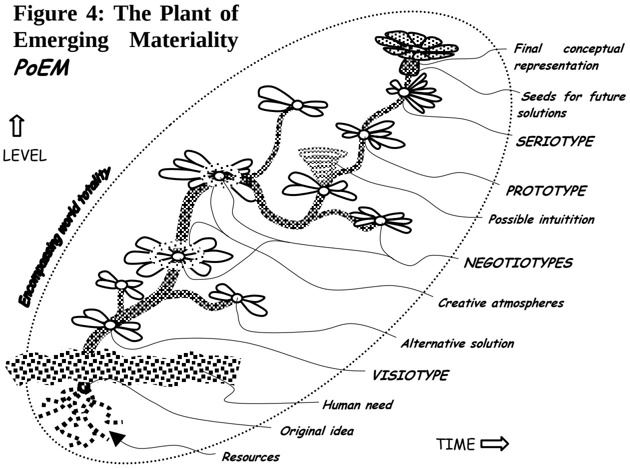
Figure 3: Individual and shared models of design conceptualisation

The physical negotiation catalyst in this model signifies any material representation. But since few restrictions exist as to the employment of Rapid Prototyping for production of such 'sponges' for absorption of dislike mentalities, the opportunity is given for iterative physical experiments with different

[1] 8-like geometry discovered by G. Fagnano in 1750

solutions to a problem. This opportunity can be seen as grownups' playing and experimenting with own and negotiated ideas in reality. The case studies showed that several repeated attempts of such a procedure can produce specified solutions but maintain creative diversity nevertheless – through development of many parallel concepts. Iterative, sense-based experiments will bear new ideas and allow integration and harmonisation of diverging positions and mentalities. Physically experienced breakdowns will easily inspire engaged minds to find new and innovative solutions to problems. Through establishment of shared atmospheres of play and wholeness experiences representing all actors' contributions, development scenarios can be achieved which resemble the above descriptions of a state of focused awareness which can unite 'subjective' and 'objective' representations. The scenarios are illustrated in the PoEM process model. This model not only suggests new terminology for material 'typing' of negotiated understandings (*Negotiotypes*), but also similar notions for *Rapid Multityping (RM)* supported typing of (early) visions and (late) test series for experienced conceptual verification in the market (through *Rapid Tooling*).

Figure 4: The Plant of Emerging Materiality *PoEM*



Integration of field based approaches in shared scenarios

A literature review of the design-related fields creativity, aesthetics, ergonomics, semiotics and technology has revealed diverging relations as to application of physicality in conceptualisation patterns. Intentional language-based *abstraction*, often through towards the end to avoid freedom space closure too early, is a registered general procedural characteristic of many of these fields which seemingly contradicts the sketched strategy. Our findings indicate that if aesthetical gestalt evaluation of assemblies is a central issue, as in all design action, perceptual postponement should be avoided. The analysis shows that all the fields can nevertheless be embraced by this framework. This can be achieved if sense feedback is integrated in a strategy of maintaining the traditional field-based conceptualisation patterns, but *chopping up abstractions* and *mixing in bodily perception* (of alternatives) all along – like one does in aesthetics and ergonomics.

It was concluded that staging of a collaborative PoEM pattern will need these summarised intentions when theory and practice are integrated:

(1) Approaching correspondence between experience and phenomenon, which involves cyclic convergence patterns where interaction between mental and material representations are harmonised through iterative wholeness experiences.

(2) Establishment of a good and creative atmosphere, which needs attunement and arrangement of deautomatisation through playful experimentation and excitation of breakdowns.

(3) Integration of diverging traditions, where splitting up but maintaining traditional field-based abstraction patterns is suggested through mixing in perception of theoretical possibilities.

(4) Merging of diversity and specificity, which can be achieved through development of parallel concepts and perceptual comparisons between them.

(5) Initiation of shared simultaneousness, where sharing of representations in context is focused and where subjective contributions are integrated through actors having to agree on only one solution in each iteration.

Research on intuitive interfaces of the formative mode

One problematic flaw of the process tooling, which was revealed during the thirteen initial case studies, is the experienced *alienation* in the reforming of a tested iteration into an improved one – when the operational interface is a mouse and a 2D computer screen. The project had access to strong and exact Selective Laser Sintering (SLS) RP technology and weak and less accurate, but faster Concept Modelling (CM). It was found that in most of the case studies CM was preferred since alienation could be overcome and reforming could be done 'intuitively' through manual grinding and application of clay. This finding was in line with the project's focus on maximisation of sense-based perception. The opportunity of integrating this option into the process through *optical 3D scanning and surface manipulation* of the resulting point-clouds through appropriate software was early identified. This would not only improve the sensitivity of the formative mode, but could also increase the speed of the reforming action considerably.

Explorative research on this opportunity has been performed in two stages.

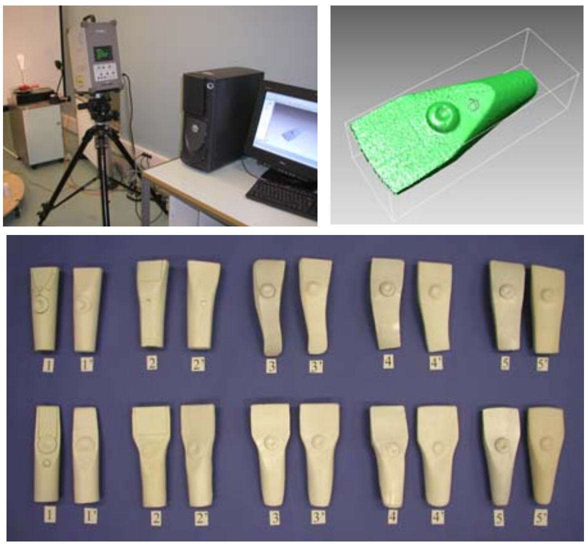


Figure 5: Scanning of manually adjusted CM hand control models, 3D model of the scan and five phases of resulting materialised models (first original and then adjustment of two alternative formal threads)

In *the first stage* three design students used the PoEM strategy plus scanning in a case study involving many iterations of tooth brush designs. SLS and CM technology was at their disposal together with a Minolta Vivid 900 laser scanner and EasyScan software for point-cloud formation and RapidForm for creation of polygon or Nurbs sufaces. It was found that if fast polygon surfacing was used, some difficulties arose in surface manipulation particularly in the meeting curves between surfaces, where the RapidForm software was not considered quite good enough. Reforming was therefore primarily done through enveloping the scans with new Nurbs surfaces, which was fast and accurate. This was evaluated as a very good overall approach based upon the high 3D modelling skills of the actors, but a less skilled and faster process was still desirable to achieve. A *second stage* project was accordingly launched with an objective to try to develop an optimised formative process using improved RapidForm software. This process was based upon repeated sequences of sense-based testing of a CM model, ideation of an improved concept, physical forming of this concept through manual reforming of the CM model, optical scanning and polygon surface manipulation (straightening) of the 3D model, CM modelling and finally new sense-based evaluation. The design case was a hand-control for a video projector. After four phases involving equipment adjustments, the process finally worked well in the fifth. It was concluded that “RP and scanning with polygon straightening appears as a very interesting tool combination for intensive conceptual development” [14]. More research is required for further adjustments, comparisons and verification of these results.

In the following will be summarily reviewed some cases which exemplify how the RP-based tool was employed to produce an empirical basis for the presented theoretical outline and scanning approach – and for the final case study.

Two conceptualisation studies

Balance sledge. One case study was based upon a vision of using a balance principle in children’s sledges to improve motor capacities through play. An innovation project was initiated in collaboration with Hamax a.s – a major European producer of sledges. A student project aimed at conceptualising different basic solutions resulted in six physical downscaled models – three representing a stiff ‘ski’ having inclined sides with curved flanges (steering by tilting) and three representing two-skis carving, two for crouching and one for standing.

Figure 6: Physical concept models of six first stage solutions

After thorough analyses of the models, the company chose the standing principle as the preferred concept and launched a redesign project with the chosen student as designer in collaboration with engineering, marketing, and production expertise of the company and with the researcher as participator. Steel mock-ups were tested by grownups and children, and the concept gradually emerged through several stages of CAD modelling, CM materialisation, testing, negotiations, calculations, changing and remodelling. In early stages detailed discussions on aesthetics, functionality, logistics, strength, tooling geometry etc. resulted in a materialised 1:1 model where improvements were roughly formed in clay during discussion meetings and completed later through 3D modelling. The finalised concept – having gone through many phases of physical harmonisations of the views of the involved actors – was materialised as SLS model, finished in realistic colours, evaluated by the company and presented to an assembly of the European dealers at the Ispo fair in Köln.

Figure 7:
Stages of a Rapid Prototyping-supported conceptualisation process

Children’s tooth brushes. Early RP-based experiments for a major tooth brush manufacturer (Jordan a.s) resulted in a new conceptual idea. The vision was that since ergonomic studies of tooth brushing indicate large-volume handles, the volumes can be used for ‘enveloping’ several items usable for motivating children’s mouth hygiene. The collaborative projects resulted in valuable learning on how RP-based experimentation can be used for engaging the design actors including parents and children.

Figure 8: Studies of CAD-based, clay-adjusted CM models involving testing and negotiating alternatives

Based in the early experiences and the by then established principles of a Rapid Multityping supported process, a concluding diploma project for Jordan a.s was organised. The project was aimed at developing four innovative tooth brush concepts for children, age one to eleven. Three students designed and developed two-material tooth brushes in collaboration with engineering, dentistry, marketing and design expertise. All the technology was at their disposal at free choice. During five defined phases they developed all concepts in parallel through trial-and-error-based evaluations of a large number of RP models. Tested experiences from each stage (with children) was the basis for new attempts, and sequences of CM models/manual reforming or new clay models/scanning and rebuilding formed the working pattern. Negotiation meetings with the company staff were held every fortnight.

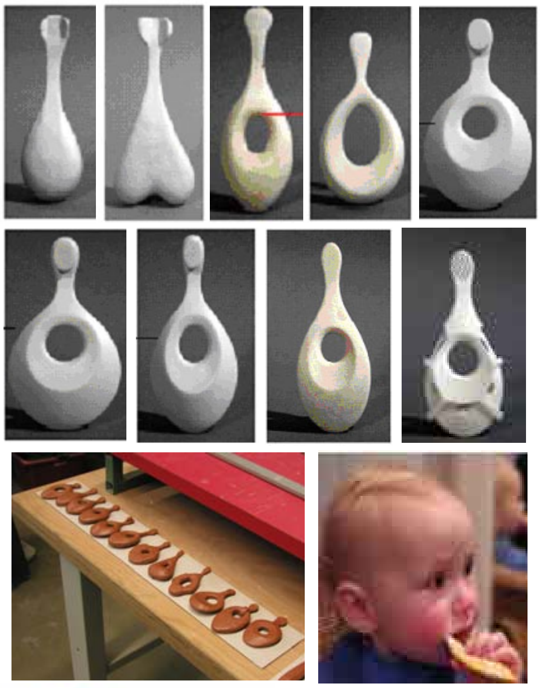


Figure 9: Some RP/clay *Negotiotypes* from the Baby concept development

A written report and a video-taped and transcribed summing-up discussion between the students, the client manager and the researcher formed the basis for process-oriented evaluations. The overall functionality of the process was concluded as *very good*.[2]

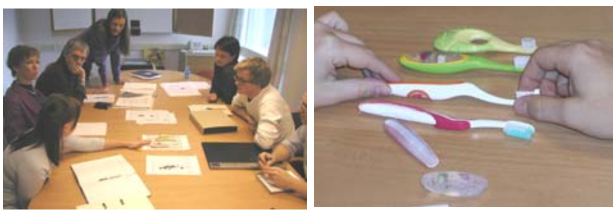


Figure 10: Roundtable negotiations and finished models of brushes

[2] The highest grade in the history of the institute was awarded and the students were later engaged by the manufacturer as professional designers – and allowed to realise their concepts for market introduction.

Visiotyping and Seriotyping

Several initiatives have during the research project employed Selective Laser Sintering technology for materialisation of *visionary product ideas* in the Fuzzy Front End phase, where a project is not established yet, but where a qualified understanding of a concept's potential is highly required for decision makers. A questionnaire-based evaluation of some cases showed that if the idea character of the presentation is thoroughly clarified, this method was seen as a very good approach to perceptual understanding of idea potential.

Figure 11: Examples of RP- produced early-stage physical *Visiotyping* of creative concepts

Production of *test series* of developed products produced through Rapid Tooling was early identified as an opportunity to reduce the very high risk of radical concepts [11], because the future users' acceptance is seen as a highly critical factor. Through acquisition of an oven for production of Laserform ST-100 'Rapid Steel' tool inserts the feasibility of producing such tools with SLS technology has been evaluated. Three Laserform inserts were produced for client companies and five for student projects. These tools were tested in production runs and most of them were found to have good performance. From those, product series of between twenty and a hundred units were injection moulded and later evaluated in actual user tests.

Figure 12: Rapid Tool example and *Seriotyping* of forks for fast-food set

These results and documentation from conferences [23, 24] indicate that cheap and fast test series of new product concepts will be possible to produce and distribute to future users in order to evaluate real market reactions. This can substantially reduce risk in creative approaches – which produces a very interesting opportunity for innovative goals.

A challenge for collaborative innovation

These and several other empirical results [6], integrated and exposed in the PoEM approach to ideation and representation, appear to have a high potential towards an effective and innovative conceptualisation process for collaborative design. In such processes technology must be adapted to support human beings – not the other way around. Challenges for future research on the possibilities this framework offers are above all its implementation in education and practice – which could produce bread while we are learning.

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