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Hybrid Design Tools Intuit Interaction

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Abstract
Non-linear, non-explicit, non-standard thinking and ambiguity in design tools has a great impact on enhancement of creativity during ideation and conceptualization. Tacit-tangible representation based on a mere idiosyncratic and individual approach combined with computational assistance allows the user to experiment, explore and manifest their ideas, fuzzy notions and mental images. One of the most difficult tasks of individual users is the externalization of tacit knowing, tacit expectations, and metacognitive feelings. Simply put, to bring your imagination alive you need encouragement, nudging, decision-making and trigger intuition. In our research we focus on the metacognitive aspects of user interaction and tool use wherein the wheels of causality are set off through coincidence, unpredictability and unexpected events. The hybrid design tools we author and build are based on the human intuitive capacity and sensory abilities to immerse in physical manipulation and tangible representation to enhance creativity and ideation process. Simultaneously we embed and implement computational design tools that assist and nudge the user during the process to represent the conceptual models, data mapping and transformative information. This transformation has a consequence of exercising the full cognitive abilities and reinforces the insight in understanding and knowledge about the problem definition and solution space. Working visually and sensory is a complex process that includes spatial information, multi perception and manual dexterity.

Keywords: Design; Intuition; Hybrid Tools; Representation; Computational; Synthesis.

Introduction

In the past four years we conducted twelve design representation experiments based on tacit-tangible user interaction. We started these use tests with very basic and elementary techniques to bring out ideas and notions as quickly as possible. The participants, mostly design students and design experts, were observed and evaluated in various design-testing environments. They were handed a variety of representation tools and materials to fulfil a number of design tasks. The first seven experiments were conceived to identify the state-of-the-art with regards to the usability, performance and interaction of analogue and computational design tools. This research was based on our hypothesis that there exists an apparent gap between the two realms. Further experimentation, in user interaction with emphasis on distributed cognition, mimic, representation and decision making, lead us to believe that the need for direct or indirect manipulation systems in conjunction with computational tools would constitute a perfect match. We noticed great differences in speed, fluidity, pleasure, performance, activity and interaction depending on the various hybrid set-ups that were tested. We concur with Donald Norman [1], "...the point cannot be overstressed: make the computer system invisible. This principle can be applied with any form of system interaction, direct or indirect". Results from our experiments show that, "…tangible interaction has merit, speeds up interaction, lowers threshold in learning curve and stimulates flow and engagement. Un-tethered two-handed interaction is adding more quality, more detail and convey higher end-output. Less demanding interfaces steam up the pace and create flow in interaction. Force feedback from material constraints transpires concentration and involvement in processing [2]".

Background

This research has a strong focus on real and virtual representation through physical manipulation, tangible modelling, iterative interaction and visualization. The aim is to embed human factors, interaction and computational technologies and merge these to congruous hybrid design tools in support of creativity in ideation for product design processing. Our background is in industrial design engineering, computational tools, human computer interaction, distributed cognition, and virtual reality. Furthermore, the research places in perspective studies and concepts of physical and digital design processing as conducted by e.g. chön, 1983; McCullough, 1996; Brereton, 2004; Woolley, 2004; Ishii et al. 2004; Bordegoni and Cugini, 2006; Sener et al., 2007; Robertson et al, 2009; as dimensions to study designers behaviour and tool use across real and virtual realms or platforms. Various case studies have been executed and data collected to give ground to developing hybrid design tools in support of individual and/or collaborative design processing. A full account of all the methods, data collection, analysis, evaluation and results would be too lengthy for inclusion here, so we refer to its primary documentation [2-3]. The hybrid design tool we discuss and apply in this design ideation study is the LFDS (Loosely Fitted Design Synthesizer) [4].

Storyboard I and II

In the following storyboards we present examples based on an actual product design process that is part of the inspiration for this research. The aim of this research stage was to gather rich descriptions of how mixed reality design environments and hybrid tools are used in practice. A simple elegantly designed wireframe whisk (Fig. 1) was used as metaphor and analogy for the design challenge to provide motivation for improving hybrid computational design tools and synthesis in design processing. In another test case we used a Pad or Tablet (Fig. 1) as a design metaphor and conducted the experiment with designer pairs.

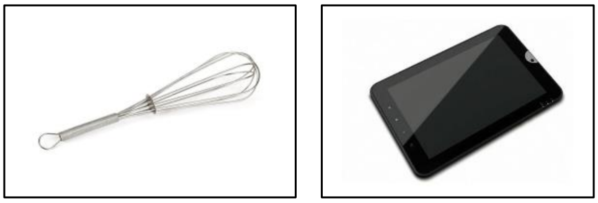

Figure 1 Design metaphor and analogy: wireframe whisk and pad/tablet.

The task given in Scene 1 was to design intuitively from 'scratch' an electric version of a whisk and in Scene 2 to design a next generation pad or tablet; in both cases some predetermined parameters and constraints were added to the design challenge.

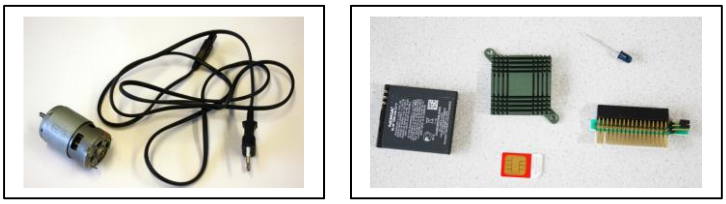

Figure 2 Component's Scene 1 (left) and component's Scene 2 (right).

These were in the form of physical components supplied for story board Scene 1; a DC-motor and power-cord with plug and in Scene 2; a battery, LED, SIM card and various electronic components (Fig. 2). The items were intended as core-functional tangible elements to evoke and trigger scale, dimension, weight, proportion and spatiality. Each experiment lasted 30 minutes and in some cases we allowed an extra 15 minutes for user-system stall, interruptions and other minor delays. All participants were first time users of the LFDS hybrid tool. All experiments were captured on video for further evaluation and analysis with consent of the participants. Our laboratory set up is shown in Figure 3.

Figure 3 Lab set-up Overview (l.), LFDS hybrid tool (m.), Worktable.

Story Board Scene 1
We placed individual Master students industrial design engineering in a mixed reality environment including a hybrid design tool LFDS (Fig. 4). Design task and challenge: electric handheld whisk.

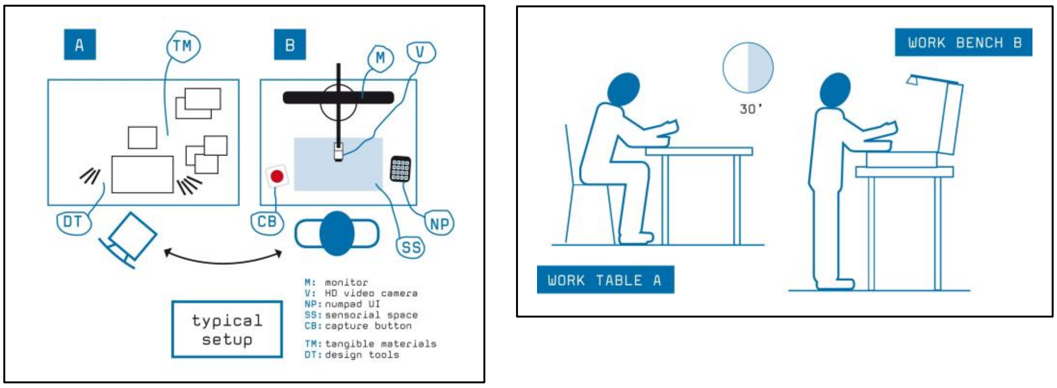

Figure 4 Typical set-up 1: A-traditional design worktable and B-hybrid tool workbench.

The participant got a brief set of instructions on the mixed reality set-up and hybrid tool including a function explanation of the num-pad user interface icons as shown in Figure 5.

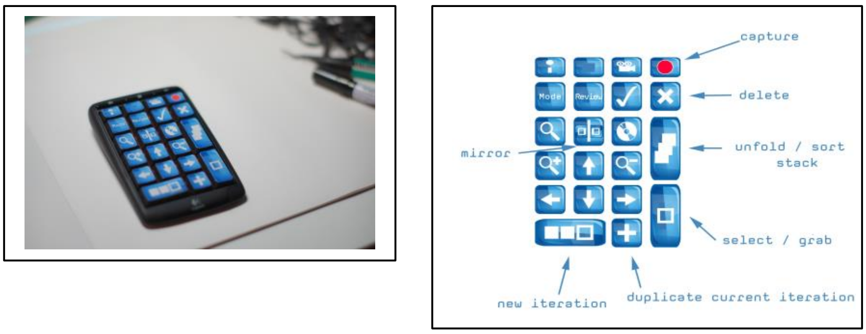

Figure 5 LFDS num-pad and user interface icons guide.

Furthermore, they were allowed to use a wide variety of other available tangible materials, traditional design tools, objects and common office tools, i.e. scissors, knife, pliers, ruler and so forth. By offering a combination of traditional and computational design tools we were able to conduct and observe multi-modal design processing and interaction. We noticed different modes of working alternating between sitting down at the worktable making sketches and rough intermittent models (cardboard, paper, wire etc.) followed by bringing these to the hybrid tool and making captures of the various iterations, manipulations and viewing the real-time virtual feedback from the system on the monitor. The user is in control of the captures by means of a special devised wireless capture button (Fig. 6).

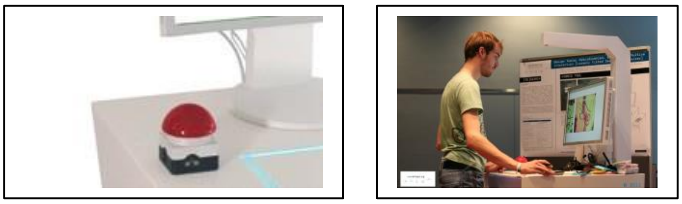

Figure 6 LFDS capture-button (left) and HD-camera in arm with monitor (right).

Above the horizontal workbench a HD video camera captures all the activity and interaction that takes place real-time, the moment a capture is made the instance will appear on screen as a representation of this choice-action. We encourage the rawshaping mode of working to manifest ideas and fuzzy notions directly onto paper as a sketch or doodle, but also create low-tech tangible prototypes from various materials and/or objects that could serve as initial idea generators. These two- or three dimensional sketches and three-dimensional rough (raw) models convey not only crucial informal idea representations, but more importantly also enhance further ideation, embodiment, externalization, communication and foster creativity. In the following chapters we will show results of these design interaction sessions. During and after the sessions there was no further discussion allowed with the experimenters. Storyboard I and II are part of our on-going research efforts and experimentations in hybrid design tools in mixed reality.

Story Board Scene 2

We placed paired Master students industrial design engineering in a mixed reality environment including a hybrid design tool LFDS (Fig. 7). Design task and challenge: next generation pad or tab.

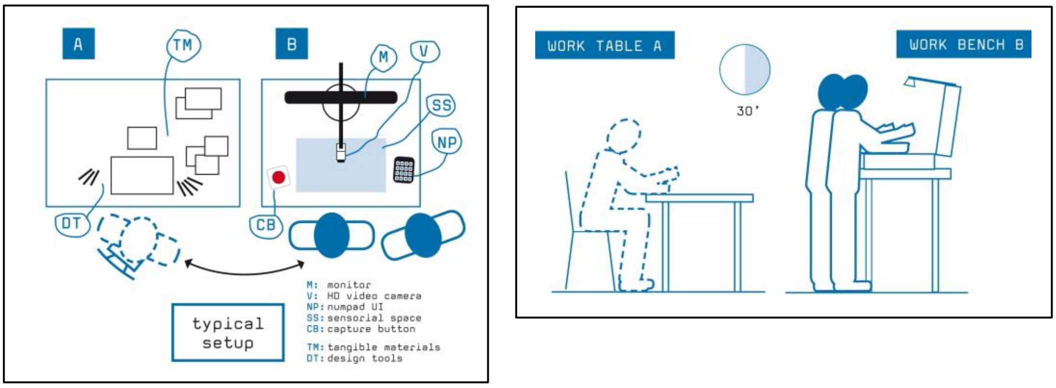

Figure 7 Typical set-up 2: A-traditional design worktable and B-hybrid tool workbench.

In this scene we placed two Master students industrial design engineering to manifest ideas and explore concepts within the mixed reality design environment. The participants showed interesting collaborative interaction, discussing the design task, weighing various possibilities and aspects of the design challenge. In most cases the initial ideas were uttered and communicated verbally, followed by interactive sketching ideas onto paper thereby indicating and pointing out meaning, specific aspects or thoughts on functionality or form. The components were inspected and included right from the start in each of the tests. After some initial sketching and project contemplation, some rough models were made. One of the pairs used a cutting mat to indicate volumetric size and used it as a template for the future handheld device. Scale and proportion give a direct tactile feedback for human factors, cognition and product interaction. This creative spark showed a very open approach to the design task and the fast creation of rough (raw) visual and tangible prototypes seemed to encourage the design process. Product dimension and physical biometric information used to physically create an intermittent prototype speeds up the interaction in sharing ideas, possible solutions and inspiration for further iteration. With the hybrid tool it is very easy to make blends of the different iterations, include ergonomic clues like gestures, manipulations and in this case manual dexterity e.g. variations in fundamental grips, balancing the object and any other expressive repertoire. (Fig. 8) The real-time virtual representations harmonize and inspire the design processing thereby creating insight and understanding during the conceptual synthesis in design creation. All captures are visualized, listed and logged as mappings of the process.

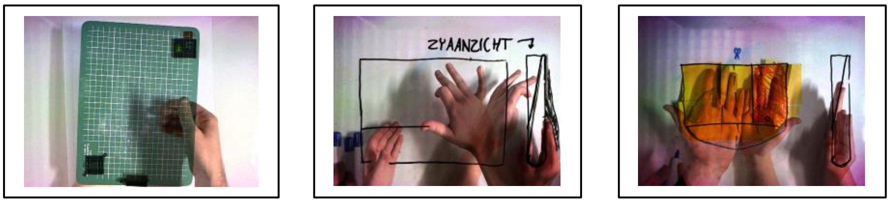

Figure 8 Blended virtual instances (LFDS) showing human factors, sketches, annotations and low-tech models.

Results and Preliminary Analysis Storyboard I and II

The design tasks executed by individual and collaborative designers showed promising results in ideation and conceptualization. The mixed reality set up supported the creative atmosphere and stimulated the participants in becoming activated thinkers and dynamic tinkerers. Within the timeframe of 30 – 45 minutes they explored and made as many possible solutions as possible without necessarily going through the whole design and prototype cycle. The number of iterations in both case studies showed a good performance rate combined with interesting, creative and promising results. However, we did not yet analyze all the interaction data, learning outcome and creativity enhancement. The number of participants was too little to fundament a proper base at this particular time. The results shown here are indicative and convey only a part of these tests and experimentations.

Results Scene 1

To transform a handheld wire whisk to an electric device the designer has to address some key issues and keep in mind a number of fundamental aspects like e.g. handling, usability, weight, safety, performance, functionality and aesthetics. The handed constraints (DC-motor, power cord) as a subset of the design task worked as a limitation and restriction in design freedom but also as a positive imaginative impulse to intuit behaviour, gesturing and scalability in creative approach. During the process flexibility, imagination and speed were essential to enhance progression, steer creative dynamics and intuit transitional information in order to get familiarized immediate and up-to-speed with the design challenge to direct the task at hand towards pleasurable product outcomes.

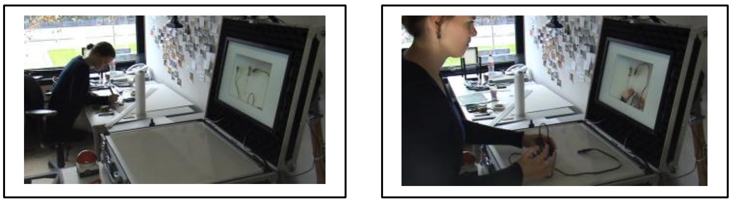

Figure 9 Multi-modal user interaction, design processing in mixed reality environment.

Working directly with materials and computational tools generates more direct insight through hands-on approach, tangible tinkering by making ideas manifest (Fig. 9, left image) and testing them real-time in the hybrid tool. (Fig. 10 – http://www.rawshaping.com)

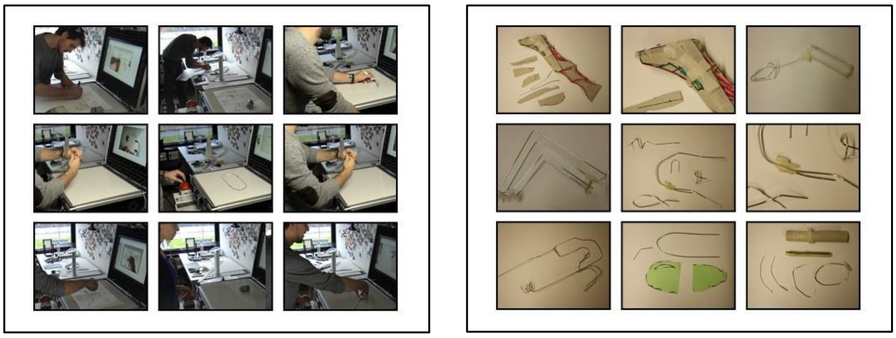

Figure 10 Analogue and digital design processing, user interaction and low-tech models.

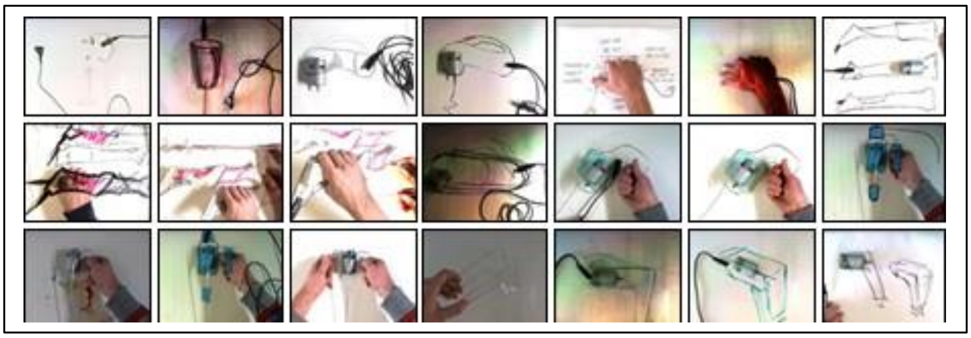

Figure 11 Virtual instances (LFDS) showing diversity and variety in ideation.

In Figure 11 we show virtual instances, captured blends of iterations that point towards the mixed reality mode of working. Participants make simple raw tangible intermediate models and create visualizations thereby blending tangibles, doodles, gestures and manipulations.

Figure 12 Virtual prototypes as possible solutions of the design challenge.

Up to know we tested eight individual students in this set-up and scene, in Figure 13 we indicate the performance in iterations and interaction time per participant. An average of 60 iterations per hour based on the data logged in the system repository of the hybrid tool.

									Total	
participant number:	1	2	3	4	5	6	7	8	8	
number of iterations	49	31	36	41	31	73	32	25	318	iterations
interaction time in min.	42	35	46	55	35	44	23	40	5,3	hrs.
average iter./min.	1.2	0.9	0.8	0.75	0.9	1.7	1.4	0,6		

Figure 13 Performance chart Scene 1.

Results Scene 2

In this collaborative design process the objective was to design a next generation pad or tab based on tacit knowledge and creative intent. Apart from the predetermined constraints, the scene was exactly the same as in the former case-study scene. In Figure 14 paired design processing is presented, showing shared multi-modal interaction, visualization, representation and communication between the actors. (Fig. 15)

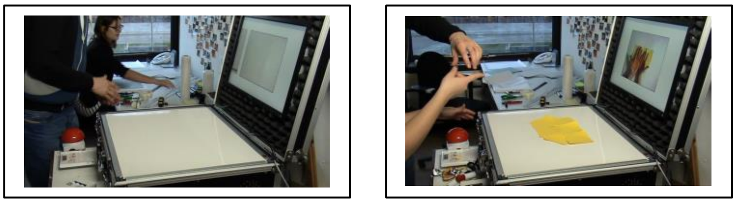

Figure 14 Multi-modal collaborative users interaction in mixed reality environment.

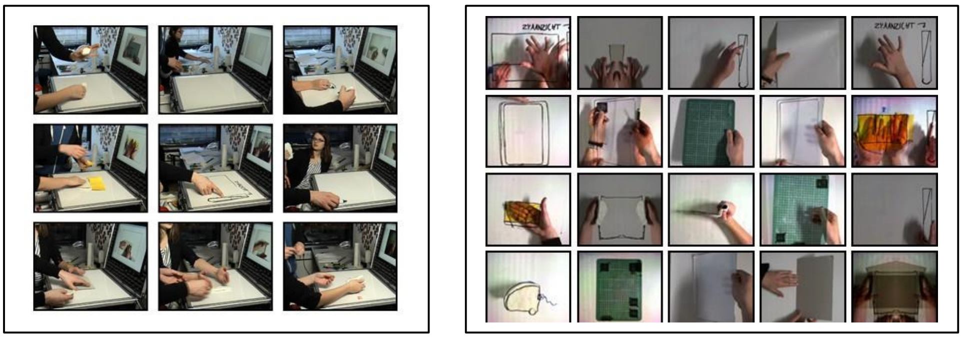

Figure 15 Collaborative design processing and various intermediate representations.

These preliminary findings show initial trials and tests to measure performance and creativity with collaborative design teams supported with mixed reality environment. We observed two pairs of Master design students that completed the design task. Figure 16 indicates the processing time of almost one hour (incl. delays) and performance indicators.

			Total	
participant number:	1	2	4	
number of iterations	46	93	139	iterations
interaction time in min.	59	58	2,0	hrs.
average iter./min.	0,7	1,6		

Figure 16 Performance chart collaborative design challenge.

Conclusion

Most product design is based on methodologies, frameworks or linear structured processing, often intertwined with very explicit information and predefined goals or targets. Especially at the onset of a design process, the phase in which creativity and freedom in ideation is essential to formulate and explore various avenues the need to be very open and unrestricted is a prerequisite to form new perspectives. Needless to say that product design ideation and conceptualization does not thrive fully with preset boundaries or preconceived barriers. [5] To enable creativity and set loose the imaginative spirit the designer should enjoy the challenges, overcome fear, and take risks. Thereby retain a certain amount of ambiguity whereas perception will solve this problem of ambiguity by using intelligent rules of thumb and, so will higher-order cognition. [6] Haptic skills should play an equal important role in the fields of design and fabrication, although no tool will be as rich a conductor as the bare hand, it may compensate by working under a greater range of conditions. [7] Practitioners are equipped with building blocks of knowledge and pre-fabricated solutions that empower them to solve design problems in their future work environment. [8] Tools are mediators in action, in our hybrid approach we like to extend welcoming both realms and benefit from human metacognitive skills combined with the enhanced visualization and computational power of

CAD tools. McCullough states, "A tool is a moving entity whose use is initiated and actively guided by a human being, for whom it acts as an extension, towards a specific purpose. Tools remain subject to our intent. The degree of personal participation, more than any degree of independence from machine technology, influences perceptions of craft in work". It is obvious that many designers are seduced by the speed of CAD, the fact it never tires, and indeed in the reality that its capacities to compute are superior to those or anyone working out a drawing by hand. [8] Still, we are the ones that can see, feel, hear, smell and touch to name the most basic sensorial skills humans posses. The hypothesis that hybrid design tools will enable designers to work and process more intuitively and fluently to bring out creativity, idiosyncrasy, craftsmanship and imagination has shown promise so far. During the product design processing experiments we observed flow of creativity, goals became clearer in time and implicit tacit knowledge applied to the design task. Conceptual models are formed the moment a metaphor or analogy is presented, however other clues in how things work come from their visible structures, in particular from affordances, constraints, and mappings. [1] The constraints we applied in our experiments caused rapid recognition and led to direct and indirect manipulation of the artifacts and tangible materials to represent initial ideas or concepts. Furthermore, metamorphoses triggered by the interaction with the hybrid design tool provoked material consciousness in three ways; through the internal evolution of type- form, in the judgment about mixture and synthesis, by the thinking involved in a domain shift. [9] Meeting a design challenge requires going beyond simply looking at the factors that influence how successful – in terms of task completion- a product-creation process will be. [10] Designers must take a much wider view of product design and look, in a far more holistic context, both at user level, experience- and human level. People, aka designers, become more vigilant in their views, however creativity is often constrained by reality…'people' need to know what reality is, so they can be productively creative within those constraints. Hybrid environments were computers are ubiquitous, but invisible, 'people' will feel encouraged, motivated, comfortable, and calm. Better interfacing with our machines in order to interface better with ourselves, better interface with information and generate knowledge or insight more quickly and visceral. If the threshold of knowledge acquisition drops dramatically, the cost of education and learning diminish and set off the wheels of causality.

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