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HCI/HMI PLEASURE: PUSH YOUR BUTTONS

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Abstract

The four pleasures; a feeling of happy satisfaction, enjoyment, entertainment and sensorial gratification. "What's your pleasure?", asked Mr. Einstein. "Push my buttons, bleeped the machine." "With pleasure...here we go...!" cried Albert and pushed some buttons on the machine interface. The machine riposted; "Creativity is the residue of time wasted, design for life is to learn how to use creativity in our daily lives to fulfill our dreams and passions. Our tools dictate the nature of our work, whereby our hands are the instruments of our mind. Often software interfaces define the boundaries of our work, but only exploration into the margins of these tools, beyond the intended use pattern can really expose these boundaries. In that sense in order for us to break out of the design paradigm embedded in software we must use it “the wrong way”. Hybrid software tools and blended spaces for design and creativity try to provide a simple, flexible and efficient workflow whilst still not limit the creative output." "Oh, thank you! Great answer", replied Albert pleased. "My pleasure!", the machine responded.

Keywords: Creativity, Design education, Virtual engineering (VE), Human behaviour in design, Technology

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1 INTRODUCTION

Design for life in a world of continuous digital technological diffusion, encompassing cyber-physical systems, ubiquitous environments and big data networks. Consequently, we immerse ourselves in these blended spaces seemingly effortless, constantly meandering between real and virtual environments. Machines and systems are incorporated, embedded and take fully part in all areas, sectors, territories, and domains of our lives to fulfil, assist and/or support our daily tasks, work, communication patterns and social lives. Everything seems connected or is connected by some sort of means, service or proxy. There is hardly any escape or possible denial of the digital revolution in our daily routines from technologically communicated, facilitated, and/or mediated interactions. Although computers are encroaching into territory that used to be occupied by people alone, like advanced pattern recognition and complex communication, for now humans still hold the high ground in each of these areas (Brynjolfsson & McAfee, 2011). Design is a key component of engineering education and has been identified as providing an opportunity for developing creativity (Petty 1983, Charyton et al. 2008, Wong and Siu 2011). Humans can excel in interactions and communication with others and possess amazing capabilities to use these complex skills to gather information or have an influence on others behaviour. However, computers and systems are getting better and better in doing virtually the same complex set of sensorial ‘understanding’ and recognition of recurring motives. Virtual assistants (robots) are quite common practice these days (i.e. services, communication, and information) and are often more cost-effective and efficient in their repetitive task fulfilment and core functionalities. Humans continue to have, at least for the time being, an advantage in the physical domain in which they use their abilities and capabilities in often advanced and complex situations in either physical or cognitive challenges (i.e. communication, psychology, cognition). People are great problem-solvers in the physical and metacognitive processes, often ambiguous, non-linear, risky, predictable or unpredictable, but always in the state of motion, explicit intention and interaction. Putnam (1981) points out that any adequate account of meaning and rationality must give a central place to embodied and imaginative structures of understanding by which we grasp our world. The structure of rationality is regarded as transcending structures of bodily experiences, as shown in Figure 1.

Subjective	———	Objective
Mind	———	Body
Liberal Arts	———	Natural Science
Human / Person	———	User / Customer
Internal	———	External
Implicit	———	Explicit
Virtual	———	Physical
Experiential	———	Practical
Human-Experiential Design	———	User-Experience Design

Figure 1. Transcending structures of bodily experiences

Our reality and experiences are shaped by the patterns of our bodily movements, the contours of our spatial and temporal orientation, and the forms of our interaction with objects. It is never merely a matter of abstract conceptualization and propositional judgments (Johnson, 1987). Our hypothesis is that embodied imagination (physical experiences and its structures), intentionality, tangibility, and meta-cognition could simultaneously ‘link’ this imagination or inspiration (individual or collaborative) with the digital realm based on natural and intuitive interaction and exploration.

2 CREATIVITY IN LIFE

“Creativity” in life is the most important ability for human beings (Yamamoto et al., 2014). Yamamoto et al. (2014) argue that creative activity is a repeat of imagination and externalization. If creators could follow this process smoothly, they could create their products more effectively. Product design and engineering are a complex set of activities beset not only by the limiting enablers but also by the unwitting impact of mediocre designs (Cross, 1984) and (Kosmadoudi et al., 2013). Von Stamm (2003) states ... "One of the big concerns for many companies is ... how to generate more and better ideas - how to become more creative." Small errors in the early design phases (fuzzy front end) may not become apparent until much later in the process or until it becomes too late. Ideation and creative tinkering is the "ability one has to conceive, or recognize through the act of insight, useful ideas" (Vaghefi et al., 1998). Schön (1983, 1987) stated that designing is complex: according to him it is about different kinds of knowledge, to develop a personal system of preferences, and use of specific language of sketching and modelling. Nowadays computational tools are the standard in design and engineering and play a crucial role in the design process. There are many views on the massive change that for example computer-aided design (CAD) caused (Robertson & Radcliffe, 2009), how it influenced user behaviour, user intent, user-experience (UX), user-interaction (UI), user-performance, dexterity, and productivity (Wendrich, 2013). Current CAD systems (enabler) are governed by rigid rules and predetermined "canonical" procedures that limit user/designer creativity and intuition (Kosmadoudi et al., 2013). The transition from masses to user-centred design paradigms sees design and engineering activity and creativity being compromised. The complexity of products and services has increased dramatically with megatronics and adaptronics. In a 'globalised' world, interdisciplinary and trans-disciplinary product development is part of everyday life. However, domain boundaries are in dire need to evaporate or be pushed-back in order to have more fluid transmission of ideas, larger spillovers of knowledge, increased crossovers of multi-disciplinary approaches, and allow for enhanced provocations in existing (conservative) domains (beyond silo fixation). Moreover, further complexity is introduced with the demand of Product Service Systems (Birkhofer 2011). To reduce the increasing complexity, the need for tools that stimulate intuition, foster imagination, and influence (behavioural) the natural user interaction is important and necessary to spur or ignite creativity across modalities (Wendrich, 2014). Design practice is to a large extent about handling complexity and a "messy" (raw/brutal) reality. However, complexity in design is not at all the same kind of complexity seen in other areas of human activity (Stolterman, 2008).

2.1 Creativity in Design and Engineering Education

Creativity has seen a surge of interest in education in recent years and this, combined with an increased emphasis on creativity in society, has been met by educators as a positive move (Craft, 2003). Csikszentmihalyi (2009, 2014) distinguished four characteristic phases in creative processes: (a) preparation; a portion of time with intensive study and conscious analysis searching for problem solutions, (b) incubation; a portion of time dedicated distance yourself to unconsciously ponder over and deliberate, (c) illumination; the moment(-s) of insight and understanding the possible solution space followed by (d) evaluation (verification) in which concepts are tested and applied (transformative ideas and mash-up of alternatives) through conscious elaboration and concise work (often highly detailed). Design and creativity are not solely about making digital virtual illusions in multiple-dimensional representations and simulate these in virtual or synthetic environments. More importantly current and future design tools facilitate interaction, imagination, and communication in such that the user(s) feels as comfortable working the digital tool as in their physical realm (mimetic) (Wendrich, 2014). It is a priority to make more adaptive learning environments in educational institutions based on pleasurable engagement, enjoyment, serious gaming and play to ignite and foster creativity. Lanier (2010) stated that some topics (i.e. design, creativity, and ideation) need the human touch and a sense of context and personal voice more than others. How is such possible, when most of our technology is based on standardisation, uniformity and conformity of ideation, presentation and representation? Colwell (2005) states, if engineers only had to follow a set of directions, we wouldn't need engineers; computers and robots can do that much. In the physical realm the use of tools show a variety and diversity in use and outcome when used by a plethora of different users. This is often due to or a direct consequence of (intrinsic) skill set, experience, knowledge, understanding and insight in tool use and its prospective usefulness. The idiosyncratic qualities and capacity will become visible directly and without any hidden surprise (Wendrich, 2011). This phenomenon is not only in the process activity but especially in the iterative quality and effectiveness of the chosen tool solution. In digital technology these aspects, of making use of the deep meaning of personhood, are often completely diffuse, consequently reducing the human capacity by illusions of bits; people degrade themselves in order to make machines seem smart all the time (Lanier, 2010). Consequently, the use of tools in itself are no guarantee for success, as 'a fool with a tool is still a fool' (Gassmann and Schweitzer, 2014). To speak with Osborn (1953) in creativity it is crucial that you produce as many ideas as possible, produce ideas as raw and wild as possible, build upon each other's ideas and avoid passing judgement. The general consensus is that bringing product design as CAD play and serious gaming (SG) mechanisms/concepts together is fundamental to the future development of next generation intuitive design environments (Kosmadoudi et al., 2014).

3 INTERACTION TOOLS IN DESIGN EDUCATION FOR LIFE

Methods, tools, and approaches used very early on in the new product development process (NPD) are often referred to 'front-end' processes (Koen et al., 2002; Cagan and Vogel, 2001). Ideation is the "ability one has to conceive, or recognize through the act of insight, useful ideas" (Gericke and Blessing, 2011). Hence, this front end of NPD is sometimes referred to as the 'fuzzy front end.' Our approach for ideation and creative processing is based on empirical research within a holistic framework (e.g. bottom-up). In combination with agile software development and fast prototyping we determine what kind of tools and/or applications target the intermediate layers and consilience between users' abilities, skills, their knowledge, and complex system requirements (i.e. interoperability, reuse). We blend the real and virtual worlds to orchestrate and prosper from the different and multitude in modalities, experiences, and interactions. This mixture of realities, as illustrated in Figure 2, allows us to freely and boundless explore possibilities, maximise on the outcomes and foster serendipitous results.

Figure 2. Virtuality continuum

In 2004 a study was conducted in order to create an overview of important characteristics for a virtual design tool for ideation and creative processing. Participants were students in mechanical engineering and industrial design engineering at the University of Twente (Wendrich et al., 2009). The study revealed that a virtual design tool can be promising only when the:

- Tool creates more insight and understanding
- Tool has low threshold in learning curve
- Tool increases processing speed in solution space
- Tool implies visual and tangible representation
- Tool triggers easy ideation and conceptualizing
- Tool generates and allows simulation
- Tool allows intuitive un-tethered interaction

According to Badia (2006) and Wendrich (2010) there are seven types of tools that give support:

- A pleasurable environment that helps the professor/facilitator. It gives the educator information regarding to several questions related to the design and development of the activity.
- Educational interaction between professor and student. It gives useful educational help that are stored in a given virtual realm.
- Educational interaction among students. It eases the work of students in two ways: it favors his individual work; stimulates the collaboration with the rest of the team members.
- An environment that helps, assist and support the students. It helps the student to keep in touch with the activity, assignment or task to be executed.
- ICT and the activity. It gives the chance to provide resources, cues, interventions and contents;
- ICT and the relationship between the professor/facilitator and the activity. The professor makes the contents and other required resources available in order to make the activity feasible.
- ICT and mobile learning technologies. Where facilitator and students can interact and communicate through the web (e.g. Web 2.0) with remote access, distributed computing and exchange of knowledge.

3.1 Mixed reality tools (hybrid design tools)

In Figure 3 we show an overview of user interaction experiments with the use of various created design tools and environments for design ideation and creative processing. We study, test, and observe integration of tacit knowledge, reflection-in-action, learning-by-doing, and tangible augmented representation during design conceptualization and ideation. For a full account of all the methods, data collection, analysis, evaluation and results we refer to its primary documentation (Wendrich, 2010; Wendrich, 2011, Wendrich, 2013, Wendrich, 2014).

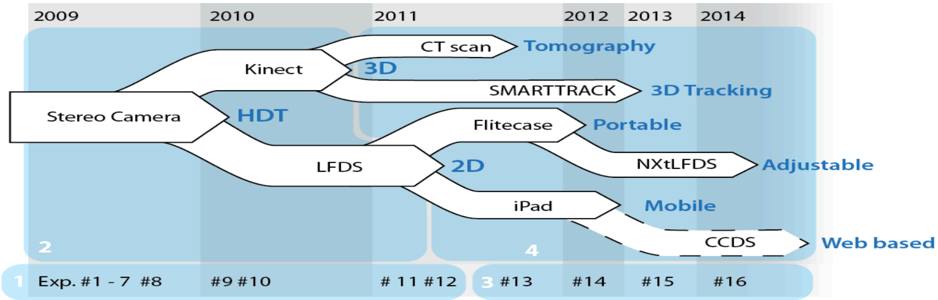

Figure 3. Overview created tools (pathways above) and executed experimentations (below)

3.2 Educational design experiments

This case-study entails a triple design ideation and representation experiment for early design activity (fuzzy front end) with three tool environments, i.e. analogue, digital and hybrid. The goal of the study was to see whether a correlation exists between ease of tool use, tool performance, tool satisfaction, tool expectations and former experience. The hypothesis was that fluency and adaptation by users would be immediate and congruent, however, we do not expect that rapid assimilation of new or innovative technology only happens when users accept that technology. Furthermore, the intuitive user acceptance and/or uptake of technology occur when the user perceives the usage as a pleasurable extension on their physical reach (McCullough, 1996, Jordan, 2000). Three separate collaborative design tasks based on the same problem definition and constraints were handed out on two different dates. During the second testing date one group of students was considered a placebo (control) group. The paired groups were formed randomly on both dates and the tasks were assigned to approximately fifteen groups per task over both sessions. All sessions were captured on video for analysis and evaluation, as shown in Figure 4. We use video interaction analysis (VIA) for data analysis of results (Jordan and Henderson, 2009).

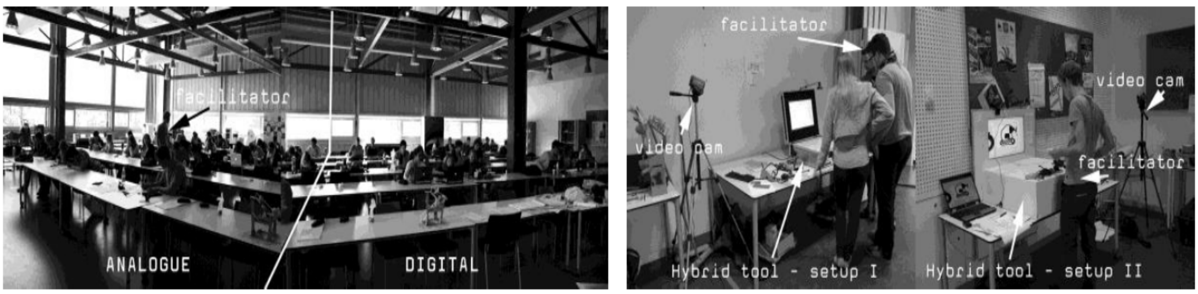

Figure 4. Top left and right; overview setup of three design experiment

In the first session the groups were assigned to complete a design task either with analogue tools (16 groups) as shown in Figure 6 or digital tools (11 groups), see Figure 7. The analogue toolset consisted of papers, markers, pencils etc. The digital tools consisted of the students their laptops (CAD software, mouse, keyboard, tablet etc.) without internet-access. The participants had to design and ideate a hydrogen car using predetermined constraints of functional elements and making as much iterations as possible in 10 minutes. The participants in this first session were handed A4-prints with constraints, as can be seen in Figure 5, Figure 6, and Figure 7. During the second session new groups were randomly formed, of which 19 groups performed the hybrid design task. They were handed 3D constraints, bottom right in Figure 5. During all the sessions facilitators would give simple instructions to the participants. However, during the hybrid sessions the facilitators would start giving instructions only after 5 minutes. This resulted in a shift from primarily 2D representations to 3D representations, displayed in Figure 8.

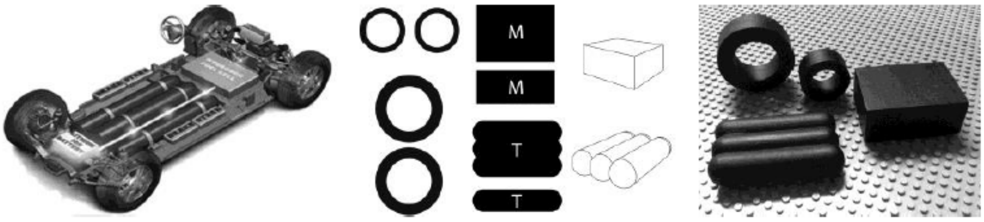

Figure 5. Left to right; hydrogen car framework, 2D printed constraints, 3D printed constraints (i.e. wheels, hydrogen storage tank and hydrogen engine)

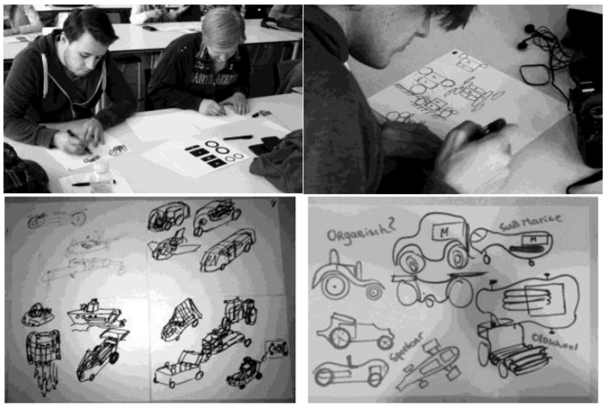

Figure 6. Analogue setup and some iterative results

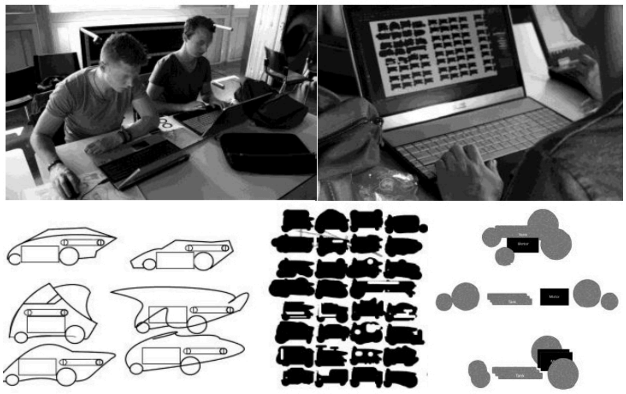

Figure 7. Digital setup and some iterative results

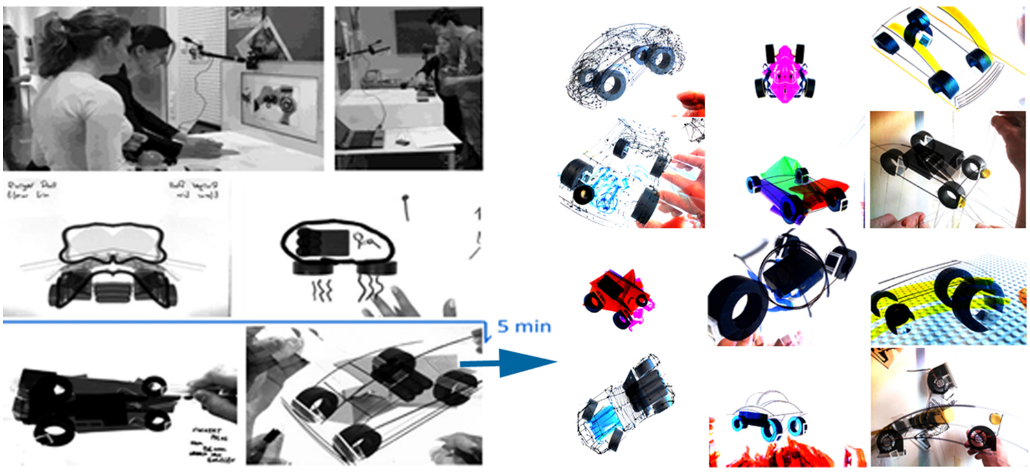

Figure 8. Hybrid setup and some iterative results before and after nudge of facilitator

The participants were asked to fill in a web questionnaire corresponding to the setup used. The subjects of the questions ranged from user experience; user interaction; ease of use; productivity; user satisfaction; exploration; user performance; user progression; expectation; and successful output.

3.2.1 Preliminary findings and results based on web surveys

The generated content indicates progressions and transformations in three dimensions whereby the 3D constraints formed the core of the hydrogen vehicle and shape aspects indicated the embodiment. During the sessions participants using the hybrid tools were more motivated and focussed on the design task. The results of the questionnaire are listed in Table 1.

Table 1. Questionnaire results three tools experiment

Questions	Results		
	Analogue	Digital	Hybrid
Previous experience with design tool?	100% Yes	85% Y	7% Y
What is your experience with design tool?	Intermediate	Intermediate	Novice
The tool was easy to use?	Agree	Disagree	Agree
The tool facilitates easy recovery?	Neutral	Agree	Neutral
The tool supports fast productivity?	Agree	Neutral	Agree
Overall satisfaction with tool?	Strongly agree	Disagree	Agree
Design task performance is fluent and direct?	Agree	Sometimes	Always
How does the tool meet you expectations?	Very good	Mediocre	Good
My creative output was successful?	Minor problem	Problem	No problem
The interface of tool is pleasant?	-	Agree	Agree
Exploring software features by trial and error?	-	Hard	Easy

This is an interpretation of the available preliminary results; participants using the hybrid tools (HT) were overall more motivated and focussed on the design task. The complexity in using the HT is below a certain learning threshold, which is reflected in the results of the questionnaire. Participants using digital design tools (DT) found these tools harder to work with, slower and less satisfying. Whereas the participants using the HT agreed that the interface was pleasant to work with and found it easy to explore new functionalities by trial and error. Most novice users had virtually no trouble handling the user-interface of the HT while exploring the possibilities of the tool and simultaneously manipulating tangibles to represent their ideas. The use of analogue versus digital tools obviously has no real surprises, often the only things lacking in students is designerly skills, designerly experience, and designerly heuristics (Stolterman,2008). Stolterman argues; "… that one reason why human computer/machine interaction (HCI/HMI) research (aimed at supporting design practice) has not (always) been successful is that it has not been grounded in and guided by a sufficient understanding and acceptance of the nature of design practice. As a consequence, HCI/HMI research has developed and/or borrowed approaches and methods not always appropriate for interaction design practice, even though they may be successful in their respective "home" fields or in research settings."

3.2.2 Preliminary findings and results based on observation

The majority of solutions executed during the AT and DT experiment were based on two-dimensional elevations, configurations, and representations. Only the AT-session showed a richer mix of two- and three dimensional visualization and iteration. Perhaps the analogue domain intuitively feels more comfortable, less constraint to make representations in multiple dimensions. Probably AT affords being less restricted in externalization, scalability and representation. The participants physically working on laptops, tablets and pads (i.e. mouse, keyboard, stylus, fingers) made mostly use of illustration based programs (apps) to create iterations and make representations. After analysis, reading feedback and evaluation of the uploaded DT content we found that 90% of the participants used MS Paint. A few used Photoshop, Illustrator or SolidWorks to represent their ideas. Results showed amongst others that:

- Tangible interaction speeds up interaction, lowers threshold in learning curve and stimulates flow.

- Un-tethered two-handed interaction resulted in more quality regarding mimicking both the symbolic form and level of detail.
- Besides tangible interaction, less demanding interfaces convey a higher iteration rate and occurrence of flow.
- VIA of experiment-sessions, in which higher iteration rates have been achieved, show that quicker interactions influences representation and enhances choice-architecture.
- VIA showed that the effectiveness and differences in approach were quantified when introduced to either 2D or 3D role models. Participants working with 2D role models were more likely to work two dimensional.
- An interesting notion is that in many cases the level of detailing in the different iterations was pointed towards an approximation of the symbolic form, instead of matching the role model.
- Focussing on the task only, without touching or using the role models and representing intuitively showed large differences in iterative results and material use. Participants that followed the role models were more precise in both the symbolic form and level of detail.
- The constraint in time resulted in "idiosyncratic form objects that stem from explicit and tacit knowledge, recognition, form mimic and loose interpretation " (Wendrich, 2011).
- Physical interaction and distribution of cognitive stimulus triggers decision moments over time and show increase in insight, spontaneity and understanding of physicality. The mind-set is affected and influenced by speedy tangible interaction thus increasing the number of iterative instances over time.

3.3 NXt hybrid design tool

The findings and preliminary results of HCI/HMI design experiments are directly used for re-iterations of our hard- and software design of the hybrid tools. In Figure 9 we show a next step in embodiment design of the hybrid design tool, incorporating a height-adjustable 27" multi-touch full HD-monitor, high-definition video camera, led light source, and high-end gaming pc.

Figure 9. Next hybrid design tool and multi-modal interaction

Figure 10. User interface and various modalities

In Figure 10 we show the user-interface (UI) with different modalities to facilitate iterative interaction (fuzzy mode) through intermediate steps (e.g. sort, stack, select, reiterate) and review coupled with choice-architecture and annotation capability (logic mode) (Wendrich, 2013a, Kosmadoudi, 2014).

4 CONCLUSION

In this paper we discussed triple design tool experimentation within education and showed results and preliminary findings based on our analysis and evaluation of the data from VIA, on-line questionnaires, participant's feedback and observations. Design experiments are pivotal, like other methodologies, for the inception and challenging of theorems. They ideally result in greater understanding and provide insight into a learning ecology (e.g. design engineering environment) - often a complex, interacting system that entails a myriad of ingredients, unconventional varieties, and magnitudes – by designing and building its parts/means and contemplate the possibility of how these portions function together to assist that process of learning. Analogue physical manipulation from distributed cognition are essential in staying in touch with reality, while at the same time using virtual reality to further and broadening of the scope of these experiences. Applying reality based interaction (RBI) concepts, such as naïve physics to an interface design may encourage improvisation and exploration because users do not need to learn interface-specific skills (Wendrich, 2014b). Overall the participants in experiments and others that worked with the hybrid design tools showed high levels of motivation. First-time users had virtually no trouble handling the user-interface while exploring the possibilities of the tool and simultaneously manipulating tangibles to represent their ideas and abstract notions. Tangible user interfaces (TUI) and interaction speeds up the processing, affords direct feedback and visualization of these interactions. The actuality and realistic tangibility of the two- and three-dimensional artefacts (low-resolution) in combination with semi-immersive reality give the user (-s) direct information as an augmentation on their realities. The real-time interaction with real objects and virtual objects through physical manipulation and virtual augmented representation affords the design processing and maximises their intuition, whilst their simulative creative flow is not hindered by an intrusive user interface or modality. Therefore, we could conclude that the process of learning is not only about knowledge acquisition or enhancement of skills and experiences, but also incremental acquisition of learning-relevant social-communication capabilities and in fact form as well interests, motivations, intentions and traits. Our intent is to create, develop and investigate tools, alternative processes and unconventional methods for educational improvements and new forms of learning in design and engineering. We understand the possible pitfalls of our design experiments; often they are conjecture-driven, frequently spread over more layers of complexity. For example, going through all the hours of video data collecting the essential and consequently taking decisions on core aspects and/or issues, even though the '…surface impression is one of non-problematic capture,'(Hall, 2000). However, the multiple sources we use for data acquisition (e.g. video, photography, computational process capturing, questionnaires, feedback, observation etc.) and our evaluation and analysis hopefully keeps the outcome to be rigorous, within empirically grounded claims and assertions (Cobb et al., 2003).

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