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THE CREATIVE ACT IS DONE ON THE HYBRID MACHINE

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ABSTRACT

Ideas are hard to find, people love to have ideas! Having lots of ideas looks like you really are very creative and that you must posses very special talents more than anybody else around you. Often you are praised for being so highly creative and so smart, that you indulge yourself in all kinds of happy thoughts about how good you are consequently daydreaming about having many more ideas in the future. We believe that anybody can be creative and has the capacity to have ideas or think thoughts that if brought to bear are so creative and ingenious that we could become envious of such a person. Our hypothesis is that if you could externalize ideas with the aid of computational machines and bring out the creative act in harmonized and holistic ways such that people can benefit and gain from it. Sharing and spreading your ideas, showing creativity without being inhibited, having confidence to open yourself up and feel free to convey your thoughts no matter how 'ridiculous' it may sound has an immediate affect on people's behavior, self-esteem and psychological condition. Creativity, imagination and inspiration go together well with doing, taking action and being motivated to carry on.

Keywords: creativity, hybrid design tools, intuition

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1 INTRODUCTION

Over the last decades we have created and implemented a plethora of design engineering systems that enable us to work more efficient, faster and effective towards problem solving, optimization techniques and decision making. The abundance in two- and three dimensional tools and software programs that have been authored, developed and build to supply the design- and engineering industry with computational systems have transformed and altered the design industry and design education profoundly. Presently computer-based design and engineering is the standard and plays an active and often dominant role in design processing. There are many views on the massive change that CAD has caused (Robertson et al., 2009), what the implications are, how it increased and allowed for more complexity, and influenced design processing especially in terms of intuition, ideation and creativity. This phenomenon subsequently shows signs of fatigue in the problem solution space, universality in outcome and repetitiveness in systematic, often linear created results as recurring patterns of design processing. These phenomena have direct implications on the human metacognitive aspects of ideation, imagination and creativity. This paper presents one view how computational systems can be used in support of individual and collaborative design processing in support of ideation and creativity. We evaluate how assistive tool technology in harmonization with the idiosyncratic design task-flow could open-up possible new perspectives and enhance the performance of finding creative solutions. We use a holistic approach, based on viewing interaction and computational systems from a user-centered perspective. Doing so we can study, design and build a variety of flexible structures on various levels of magnitude and complexity, simultaneously agilely fitting and adapting details into these loosely defined structures as needed and/or required. This work is partly grounded on the framework created by Mistree and Muster (1985) on design harmonization and holistic design support systems. Moreover, we concur with Langley et al. (1992) that for human problem solving the use of an information-processing system that creates problem representations and searches selectively through trees of intermediate situations, seeking the goal situation and using heuristics to guide its search could be a promising path.

2 MOTIVATION AND PREVIOUS WORK

Our explorative and fundamental research is based on hybridization of real physical interaction and synthetic virtual processing with computational systems. We rely on the intuitive human capabilities and other meta-cognitive capacities of processing in ideation and conceptualization. In Figure 1 a topical word cloud illustrates the hypothetical research field and maps the explorative nature of our work in the domain of design engineering. Clear motivations for the study of computational creativity are: (1) to gain insights and understanding in HCI and the intuitive qualities of creativity; (2) to design and build tools to assist and support human creativity; (3) to author systems to enhance creativity and ideation; and (4) to develop natural feeling user-interaction in computational creativity.

Figure 1. Domain topical word cloud.

Previous research and work executed by us places in perspective studies and concepts of physical and digital design processing as conducted by e.g. Schön, 1983; McCullough, 1996; Csikszentmihalyi, 1996; Brereton, 2004; Woolley, 2004; Ishii et al. 2004; Bordegoni and Cugini, 2006; Sener et al., 2007; Robertson et al, 2009; Kahneman, 2011; Bergamasco and Bardy, 2012 as dimensions to study designers behaviour and tool use across real and virtual realms or mixed modality platforms. 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 (Wendrich, 2010, 2011, 2012).

3 PRODUCTIVITY AND PERFORMANCE VS PLAY AND JOY

Most processing is goal-oriented and result-driven wherein productivity and performance is being measured in time related to cost and stimulated through the implementation of e.g. methods, efficiency, value creation, cost function and other parameters to increase gain, output and profitability. In product creation processing (PCP) and creative problem solving (CPS) in particular during the 'fuzzy-front end', the need for these productivity and performance enhancers is not strictly necessary or absolutely required. Indeed results are desirable but do not have to be enforced e.g. under time constraints, to reach the desired or expected goals in the initial stages of the ideation and creativity phases of the design process. Nowadays the emphasis often is on direct, real-time and instantaneous results stemming from supposedly highly effective and efficient procedures to fulfill specific requirements, desired affect and support instant gratification. The need for speed, high transition and rapid manifestation became an intrinsic part of our quotidian life often surpassing the human dimension in profound ways. The desire to be in control of your wants and needs anytime, anywhere and anyplace has been facilitated and made possible by information and communication technology (ICT). However, we propose that in many occasions a more leisurely, slower and quiescence approach could be just as desirable or required. Moreover, a balanced harmonization between slower (System 2) and faster (System 1), as stated by Kahneman (2011), in ideation could make a significant contribution to a creation process and possibly lead to different kinds of productivity, performance characteristics and efficiency. According to Kahneman (2011) the automatic operations of System 1 generate surprisingly complex patterns of ideas, but only the slower System 2 can construct thoughts in an orderly series of steps. We adapted the aforementioned perspective on our framework in the creation of our hybrid computational approach. This attitude is in direct correlation with the adoption of alternating processing speeds in our system-architecture. The tools we authored and build are loosely based on the interaction between the two systems framework. In such we argue that in perceiving the world around us there is no good or bad, true or false interplay, just a slight but necessary readjustment of current attitudes towards design processing in favor of play, fun and enjoyment in support of flow, exploration, elaboration and incubation. Csikszentmihalyi (1997) indicates, that the elaboration of an idea into function as the one that takes up the most time, involves the hardest work and comes with much perspiration and perseverance.

3.1 The Workbench Approach: An Assistive Creative Design Environment

Workbenches are invented and made to support physical and tool activity by users (i.e. professionals, layman, craftsman) to facilitate their work process and task flow. There are many types and varieties of workbenches and specially adapted to a particular activity or specific domain.

Figure 2. Common workbench and hybrid workbench.

The workbench metaphor used in the creation of an interactive environment including a computational tool to support design processing, as illustrated in Figure 2, builds on the notion that such a hybrid environment could spark intuition, trigger skill-sets and brings out tacit and explicit knowledge. Furthermore, it might spur the intrinsic motivation of users (i.e. designers, engineers, architects, and artists); enhance the appreciation for one's own and others' accomplishments, builds on self-esteem and drives towards the externalization of ideas through transformation of creative processes. At the same time by working standing up it is easy to stay dynamically involved, step back once in a while, reflect, pose, ponder and zoom out on your creative activity (incubation).

3.2 The Hybrid Machine

In 2009 we presented the first prototype of a hybrid machine with a stereo-camera capturing system and monitor for viewing and representation of physical user interaction with tangible materials and objects. In 2010 we created another hybrid machine named LFDS [loosely fitted design synthesizer] solely based on COTS-components including a standard computer with Windows 7 OS, high-definition video camera and monitor. Peripheral devices needed for interfacing with the hybrid system are a standard keyboard, mouse, wireless capture-buttons and wireless numpad. In 2012 we created a rawshaping app (RST App) for the Apple iPad that is congruous with the hybrid tool systems. All tools are shown in Figure 3.

Figure 3. RSFF tool (left), LFDS tool (middle), RST app iPad (right)

The tool affords traditional and computational design processing to enhance and stimulate heuristic shape ideation, low-fidelity modeling, tangible interaction and virtualization. The horizontal workspace affords the multi-modal user interaction enhanced with capture buttons (hand- or foot controlled) to capture iterations and a simple user-interface with a limited number of function actions as illustrated in Figure 4. The virtual vertical workspace (monitor) functions as a window, a window through which one looks into a virtual world. The tool affords two modes of operation, as illustrated in Figure 4. The first is a 'fuzzy mode' for ill-structured 'iteration-galore' processing during creativity and ideation sessions. The second modality is the 'logic mode' where choice-architecture affords the user (i.e. designer, engineer) to select, choose, sort, annotate and save the iterative task-results. This mode also offers a 'loosely fitted mapping' or 'matrix mapping' visualization option to review and synthesize generated content stored in the data repository.

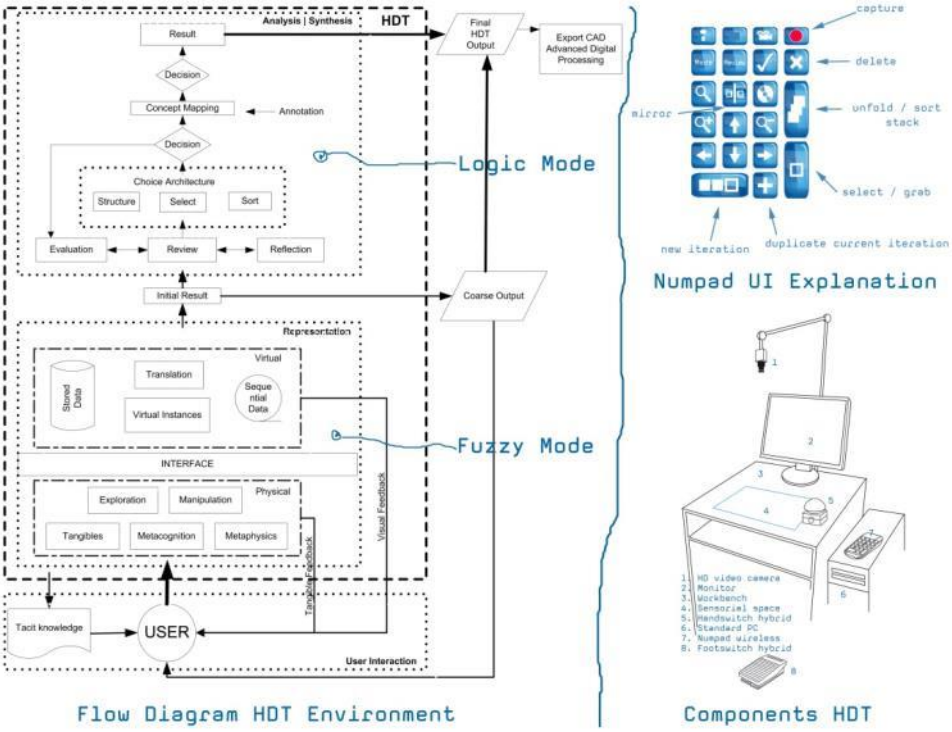


Figure 4. Flow diagram of user-centered interaction with hybrid design tool environment.

In this experiment the participants only use the 'fuzzy-mode' of the hybrid design tool for externalization and representation of ideas. The ideas selection and iteration choices are made individually by the participants to finalize the design task.

4 CREATIVE THINKING AND METACOGNITIVE PROCESSING

In externalizing ideas we feel that 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 judgment (Osborn, 1956). Multimodal interaction with the hybrid machine is to capture as many iterations as possible during design processing whilst simultaneously getting instant virtual feedback from the monitor. Physical two- and three dimensional presentations in e.g. sketches, drawings or low-resolution models made in the process will enrich the process and help to enhance the insight and understanding. Goethe's 'Connect, always connect' seems to be the motto of the designer as, out of the fluid raw material of its experiences, it selects and shapes patterns and relations (Koestler, 1964). Working this way will facilitate knowledge extraction and the creation of possible solutions. The user creates and manifest ideas; externalize thought patterns; makes captures (input) of transformations and manipulations. At the same time when the capture is made the system nudges an output that triggers, distorts, surprises or ruptures the perception and thought process of the user as illustrated in Figure 5.

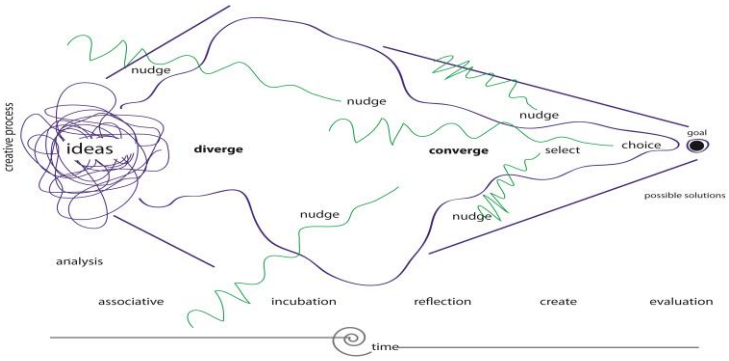


Figure 5. Creative processing with the hybrid design tool.

The captured content is either represented as a series of individual virtual instances or as blended stacks. The serendipitous layers transpire a rich visualization of abstract concepts generated by the user (i.e. designers, engineers). The act of creativity in conjunction with a hybrid machine involves the production of novel ideas, tangible and virtual abstractions as shown in Figure 6.

Figure 6. Examples of iterative virtual abstractions.

Designers or engineers do not necessarily need a computational machine or tool to convey their ideas, fuzzy-notions or imaginations. There is not enough reality in them to justify a sole reliance on digital tools alone; a cross-modality hybrid blend of tools would have much more effect. In order to facilitate a creative environment for play and design in support of ideation and creativity, we just need to be able to explore freely and discover intuitively while thinking-on-your-feet, doing-in-action and reflection-in-action (Schön, 1983). As Mlodinov (2008) stated that user behavior is not only unpredictable, but also often irrational, and it is impossible to precisely know and control the circumstances and much is left to chance. The design tool helps to uncover and benefit from these random processes and random user behavior. The machine progressively nudges towards new iterative steps or transformations to follow up, generate workflow that subsequently results in highly productive creative activity, playful interaction, rich and engaged creative processing. To paraphrase Dalcher (2006) we concur that design is neither orderly nor linear; it implies a continuous and active search to resolve trade-offs and satisfying constraints.

5 EXPERIMENTATION IN HARMONIZATION OF CREATIVITY

In the following educational experiment we apply the hybrid machine to test multi-modal creativity and ideation processing. We present findings and results from a collaborative-individual design task executed with the assistance of a hybrid design tool (LFDS).

5.1 Design and participants

We assigned 88 undergraduate design students to participate in this experiment and paired them in 44 groups divided over two hybrid setups. Each test setup consisted of one LFDS hybrid design tool (HDT) and one facilitator as shown in Figure 7.

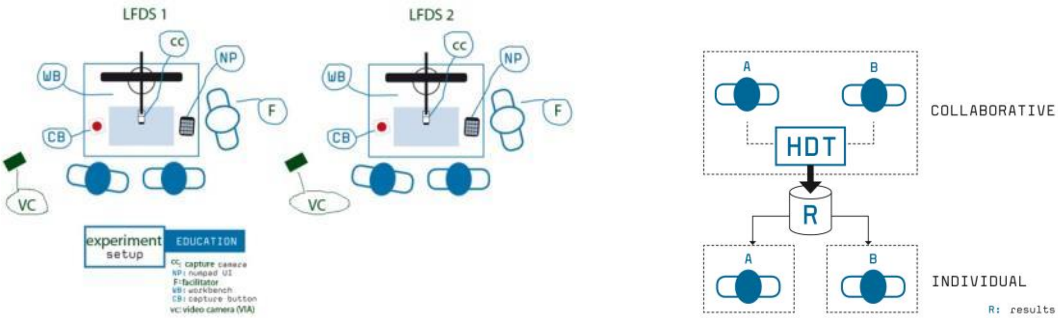


Figure 7. Experiment setup and design task procedure including two hybrid machines.

5.2 Procedure

The design task was to collaboratively design and to create an automotive or mobility concept from scratch in five minutes time. An analogous 'set-of-wheels' were handed as pre-determined constraints to be used during the iteration process as shown in Figure 8 on the right.

Figure 8. 'Set-of-wheels' metaphor and typical iterative sequence with merged stack.

For the representation of ideas they were asked to use traditional design tools, two- and three-dimensional real-world materials and the design tool. The facilitators explained the design task and gave some basic instructions on the use of the design machine to get started. Figure 9 shows collocated user interaction during design processing in the hybrid design environment.

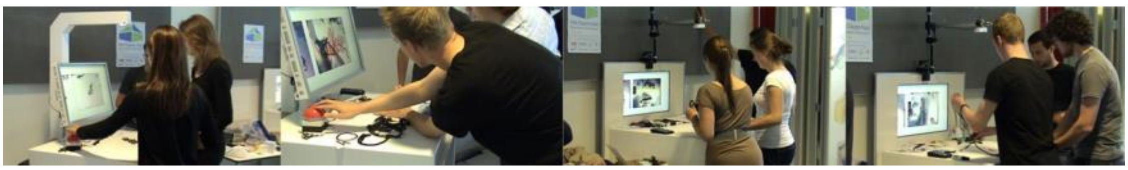


Figure 9. Impression user interaction in experiment environment.

The procedure as illustrated in Figure 7 (on the right) was as follows; first off to work collaboratively assisted with the hybrid design tool to collectively generate as many iterations as possible within five (5) minutes; secondly, to individually design final design solutions based on their collective iterative data sets. Furthermore, all the participants were granted access to the collective data repository of both hybrid systems for inspiration and creative mash-up. Working with the hybrid design tool generates captures of iterations and blended iterations that become merged stacks as illustrated in Figure 8.

5.3 Results and analysis

All the interaction and design processing was videotaped and all participants were made aware of the video recordings. We use VIA (Video Interaction Analysis) (Jordan & Henderson, 1995) to analyze and evaluate e.g. face-to-face interaction, tangible modeling, artifact transformation, iteration-galore, gestures, choice-action, decision-making, expressions, signs-of-flow and autotelic activity. In this experiment we validate the quantity of iterations, iteration speed and performance. We assessed a total of 7 hours in video footage (2 x 3,5 Hrs.) of collaborative interaction. This enabled us to make a quantitative analysis and evaluation of the creative design assignment with assistive hybrid technology. A total of 983 iterations were made during the sessions by the 44 groups. The test duration was 5 minutes per group, in most cases we allowed for some extra time due to stagnation or other minor ruptures. Table 1 show diagrams of the iterative results made by the paired groups during the sessions with LFDS I and LFDS II environment. Table 2 show the iterative results from session LFDS I. In Table 3 we show the iterative results from LFDS II.

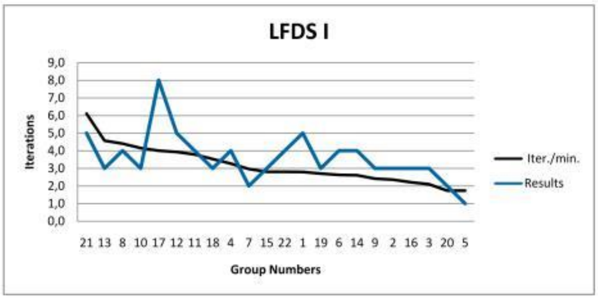
Table 1. Group sessions results and validation LFDS I and II.

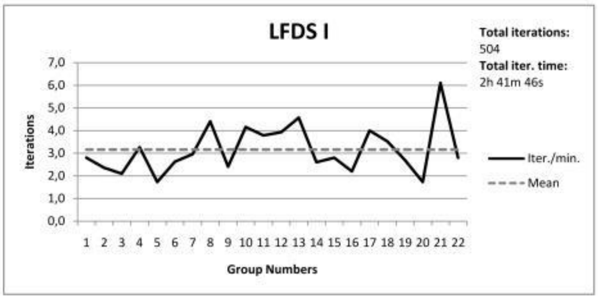
LFDS I					
Group nr.:	Nr. Iter.:	Nr. Merged:	Total Iter.:	Tot Iter. Time:	Nr. It./Min.:
1	17	5	22	0:07:52	2,8
2	11	3	14	0:05:56	2,4
3	12	3	15	0:07:09	2,1
4	17	4	21	0:06:26	3,3
5	12	1	13	0:07:30	1,7
6	29	4	33	0:12:34	2,6
7	16	2	18	0:06:05	3,0
8	29	4	33	0:07:30	4,4
9	18	3	21	0:08:43	2,4
10	24	3	27	0:06:30	4,2
11	22	4	26	0:06:52	3,8
12	26	5	31	0:07:54	3,9
13	25	3	28	0:06:08	4,6
14	16	4	20	0:07:40	2,6
15	16	3	19	0:06:47	2,8
16	14	3	17	0:07:43	2,2
17	24	8	32	0:08:00	4,0
18	17	3	20	0:05:40	3,5
19	12	3	15	0:05:33	2,7
20	7	2	9	0:05:11	1,7
21	31	5	36	0:05:54	6,1
22	30	4	34	0:12:09	2,8
		79	504	2:41:46	Mean 3,16

LFDS II					
Group nr.:	Nr. Iter.:	Nr. Merged:	Total Iter.:	Tot.It.Time:	Nr. It./Min.:
1	10	3	13	0:06:17	2,1
2	14	2	16	0:05:03	3,2
3	38	5	43	0:07:10	6,0
4	22	2	24	0:07:19	3,3
5	19	4	23	0:07:36	3,0
6	19	4	23	0:10:13	2,3
7	25	3	28	0:06:46	4,1
8	24	3	27	0:07:39	3,5
9	24	6	30	0:09:04	3,3
10	14	2	16	0:06:24	2,5
11	16	3	19	0:07:10	2,7
12	11	5	16	0:07:16	2,2
13	14	3	17	0:06:23	2,7
14	14	4	18	0:05:02	3,6
15	18	4	22	0:07:14	3,0
16	18	3	21	0:06:23	3,3
17	27	7	34	0:09:47	3,5
18	11	3	14	0:05:30	2,5
19	11	3	14	0:03:41	3,8
20	26	5	31	0:04:07	7,5
21	8	3	11	0:06:00	1,8
22	16	3	19	0:07:20	2,6
		80	479	2:29:24	Mean 3,29

The LFDS I session lasted a total of two hours and forty-six minutes. Twenty-two groups made a total of 504 iterations. They compiled a total of seventy-nine (79) merged stacks. The stacks represent a possible solution to the design task and function as inspirational content for the final individual execution of the assignment. The mean for session LFDS I is 3 iterations in 7.3 minutes of processing time. There were ten (10) groups with more than 3 iterations per minute and twelve (12) groups with 3 or less iterations per minute as shown in Table 2. Successful outliers were group 21 with 6.1 iterations in little over 5 minute interaction time. Group 20 and 5 were the least successful in this session with an average score of 1.7 iterations.

Table 2. Group results of validation sessions LFDS I. Left histogram shows group results in number of iterations per minute. On the right the total of iterations in accrued time.





The LFDS II session lasted a total of two hours and twenty-nine minutes. Twenty-two groups made a total of 479 iterations. They compiled a total of eighty (80) merged stacks. The stacks represent possible solutions to the design task and used as inspirational content for the final individual execution of the design task. The mean for session LFDS II is 3.3 iterations in 6.7 minutes of processing time. There were nine (9) groups with more than 3 iterations per minute and thirteen (13) groups with 3 or less iterations per minute as indicated in Table 3. Successful outliers were group 20 with 7.5 iterations in little over 4 minute interaction time. Group 21 was the least successful in this session with an average score of 1.8 iterations. After the parallel sessions all the participants were supposed to download the generated collaborative content from the data repository. To finalize the assignment they had to individually design final automotive or mobility concepts. We allowed one week executing the final concepts. Table 4 shows the overall end results of individually executed task performance of this experiment and give an indication of the potential benefit and gain in hybrid design processing.

Table 3. Group results of validation sessions LFDS II. Left histogram shows group results in number of iterations per minute. On the right the total of iterations in accrued time.

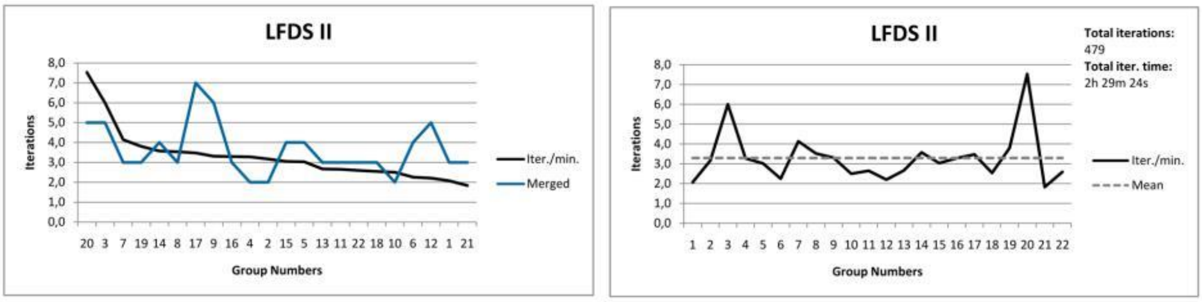


Table 4. End results overall collaborative-individual performance.

Experiment Individual Performance	LFDS I	LFDS II	Combined
total number of participants	44	44	88
total individual end results	36	31	67
total participants not finished	8	12	20
overall task completion:	82%	71%	77%

5.4 Collaborative-Individual Ideation and Final Representation

In Figure 10 a random selection of twenty merged stacks to represent virtual iterative results from captured collaborative interaction with the hybrid machine. The iterations show a variety and array in possible solutions and new starting points for further iteration. Numbers indicate session and group.

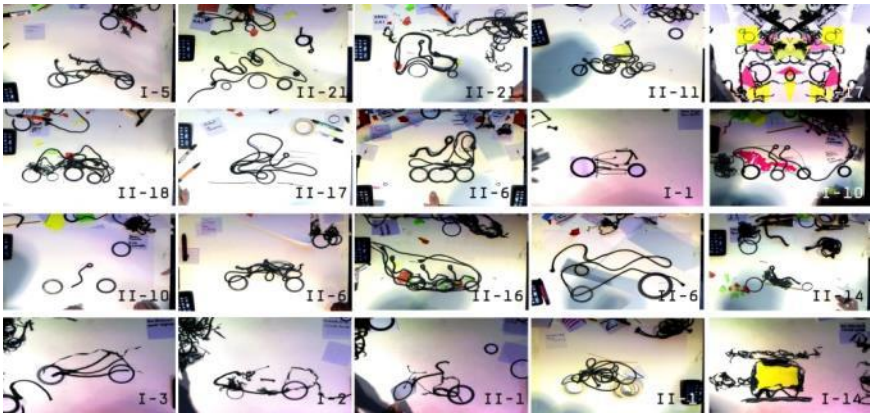


Figure 10. Virtual merged stacks of collaborative iterative processing.

In Figure 11, 12 and 13 we show randomly selected final results of collaborative iterative sequences and final individual design concepts. A variety of software programs were used to make final presentations of their work (i.e. Blender, Photoshop, Illustrator). Some students used hybrid modes of working by making low-resolution physical models and digital photography. The final assignments were uploaded via the Blackboard course management system.

Figure 11. Virtual merged stacks of collaborative iterative processing.

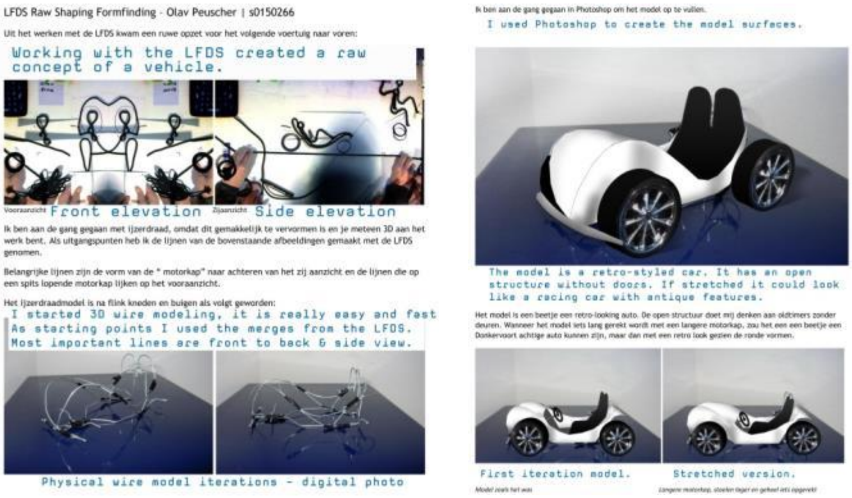


Figure 12. Virtual merged stacks of collaborative iterative processing.

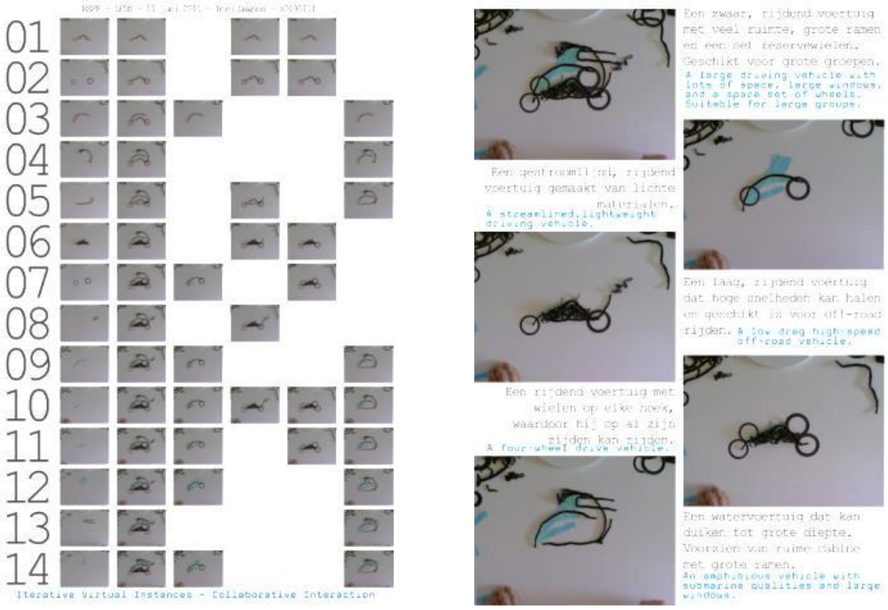


Figure 13. Example collaborative-individual iterative processing.

5.5 Enjoyment and pleasure

The users (i.e. designers, engineers) are in control of what is being captured. In the collaborative processing both participants can have an individual or mutual vote on what content will be captured. Communication, face-to-face discussion, making selections and choices on what to keep and what to delete are part of the interaction process while processing. Deliberation and reflection on the process occurs to utter, point-out issues and directs outcome. In Figure 14 we show empathic user behavior, facial expressions and gestural indicators of motivation, enjoyment, pleasure and concentration.

Figure 14. User interaction showing enjoyment and happiness.

6 CONCLUSION

Creating creative environments, in this case a microenvironment needs to address the human dimension and provide comfort zones to support the creative abilities and human capacity to emerge. Familiarity, aesthetics and quiescence in layout and design are an important factor to support these aspects. Ease-of-use and interfaces that intuit users require appropriate testing and exploration over much iteration of continuously-usable prototypes. Berkun (2010) postulates that we want creativity to be like opening a soda can or taking a bite of a sandwich: mechanical things that are easy to observe. Yet, simultaneously, we hold ideas to be special and imagine that their creation demands something beyond what we see every day. Understanding users and interaction is a matter of approximation and are characterized by ambiguity, uncertainty and complexity. Therefore, successful design in an unquantifiable world thus relies on judgments and choices as stated by Ferguson (1977). In our experiment we gathered useful data for further optimization and possible adaptation of the hybrid design tool. Participants' expectations of the prototype were rather high, even when we informed them it was merely a prototype. Some participants wondered why the prototype lacked features they expected out of experience with similar systems (e.g. multi-touch). Once a good number of iterations have been made, created and captured the participants realized the potential and possibilities that the hybrid modalities have to offer. The hard part in any process, but especially in solving creative problems (i.e. design task) is to get started. In our observations of the process and analysis of the results we see some gain and benefit in getting the process started due to the hybrid tool environment. Working this way triggers the initial process and flow of ideas and iteration-galore. Furthermore, the collaborative aspect had a beneficial influence on the task execution and outcome. The performance results show a significant difference in output results between the collaborative and individual part of the design task. Some participants failed in finalizing the design task. To conclude some written feedback from participants indicate and show their enthusiasm for the executed hybrid design task; "…I'd like you to know that this was a very cool assignment! BRAVO!!!"; "…I regret to say that the session only lasted 3-4 minutes...we really enjoyed it!"; "This was really a nice way of brainstorming with a computer. Lots of possibilities, educational, and fun to do!" This contributes to the validation of our hypothesis with regard to the potential beneficiary aspects of our research approach.

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