Integrating Technology, Science and Creativity – A Challenge for Collaborative Settings in Geodesign

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Abstract

The current debate on Geodesign methodology is focussing on complex IT-based workflow descriptions that all actors involved in the Geodesign process have to accept and to follow as a team. This paper argues that the full potential of the iterative Geodesign circle between geo-data mapping, designing, sketching, GIS-analysis, simulation model runs and spatial representation can only be realized, if we manage to set up a collaborative framework, which does not assign the same roles to all participants, and which does not fix them to a given technique. The framework must enable people having different skills and viewpoints who usually do not cooperately work together. The authors discuss the three most crucial fields of differences, interfaces and synergies, which lead to a better methodological and organizational framework of cooperation for the GeoDesign process. Connecting systems and design thinking, individual skills and teamworking, analogous and digital techniques are considered as key challenges, discussed and illustrated with examples from our own Geodesign activities.

1 Introduction

The core job of Geodesign is to establish an iterative circle between geo-data mapping, designing, sketching, GIS-analysis, simulation model runs and spatial representation. As a focal methodological approach the use of geo-information directly or processed by spatial analysis and statistics, simulations, geo-processing models and Multi Criteria Analysis is used to develop ‘designs or ‘plans’ which are optimized by adaptive loops through impact analysis and participatory communication (DANGERMOND 2010; FLAXMAN 2010; SCHWARZ-V.RAUMER & STOKMAN 2012; STEINITZ 2012).

The complete iterative loop of Geodesign requires very different skills: On the one hand analytical and technical knowledge relating to the application of GIS and different techniques of spatial analysis and simulation, on the other hand creative skills of conceptual design, visualization and presentation. These skills are usually connected with very different professional backgrounds or very different personalities even within the same profession. Seldom do they work together, as their different way of thinking, different methodologies and different professional languages disconnect them and create problems in cooperating: The GIS specialist as the more analytical, systematic type suspects superficiality and piecemeal in the approach of a designer, while the designer as the creative, artistic, intuitive type suspects bureaucracy and boredom in the work of the GIS specialist.

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However, these differences are not necessarily an obstacle for the integration of the approaches. To the contrary: In terms of Geodesign the skills of different individuals are actually very needed and usually one individual cannot possess all the skills necessary to complete the full Geodesign circle. Geodesign could serve as an important contribution to bring back the designers' type of intuition, creativity and emotion into the process of data analysis and representation, while at the same time it contributes to a new designer's perspective, driven by a better understanding of man-environment interactions and based on new collaborative design settings (SCHWARZ V.RAUMER & STOKMAN 2012).

Therefore we want to introduce the three most crucial fields of differences, interfaces and potential synergies between different modes of working – in order to enable a fruitful and creative implementation of the Geodesign idea. This would integrate different individuals into a diverse, inhomogeneous Geodesign team, creating a workflow between people with very different skills. The first topic discusses the differences and possible connections between the two working modes of system thinking and design thinking. It recalls that both planning and design benefits from system concepts and abstractions which consider spatial realities as a co-development of patterns and processes. The second topic considers that the Geodesign process has to enable both for individual, disciplinary work and interactive, interdisciplinary teamwork – and their relations and interactions when they are combined together for a collaborative workflow. Finally we discuss the differences and possibly synergies between digital computation and analogue techniques – which is often considered an IT-issue but at the end stems from a narrowed view on Geodesign.

2 Connecting System Thinking and Design Thinking

2.1 System thinking

System thinking recognizes the dynamic and interconnected nature of all the different parts of the world that we live in and it relates the physical appearance of space to the spatial processes that shapes and continuously changes it. In this sense, space is not a fixed, defined form, but is continuously generated by the natural flows of matter and energy, the social and technical processes of spatial alteration and the corresponding socially and culturally influenced perception of space.

The discipline of Landscape Ecology has developed tools for modelling and simulating ecosystem flows, which can help to get a better understanding about man's influences and responsibilities towards a sustainable management of services related to eco-system flows. These tools enable to evaluate impacts over large areas, relating to complex factors and integrating the factor of time. However matter and energy flows in cities as *urban* landscapes are constituted of much more complex regimes and compositions compared to agricultural or rural landscapes, as they are not only man-managed but also man-made. To consider them as a spatio-dynamic system of matter and energy flow – ergo as a constructed ecosystem – provides a basic model, which could serve as an appropriate framework to optimize the capacity of the land to meet human needs as a guideline for sustainable urban layout and development.

However water and airflow systems, material flows, biodiversity management and soil protection are only rarely considered as basic issues when implementing urban planning. There exists a lack of consequent and creative implementations of an appropriate urban landscape ecosystem approach as a guideline for sustainable urban layout and design. This framework should respect the three basic elements of system thinking:

- careful simplification,
- structural representation (causes-effects, elements-links, flows and levels, patterns),
- consideration of dynamics and complexity.

2.2 Design thinking

Design thinking is traditionally related to designers, architects and engineers and is a methodology for the creative resolution of a task or problem, by "devising courses of action aimed at changing existing situations into preferred ones" (SIMON 1969). In contrast to the scientific, analytical approach, it does not start with gathering data and defining all possible parameters in order to define a solution. It starts the other way round: It uses experience, intuition and creativity to suggest a solution in the form of an "experimental hypothesis" (SCHÖN 1983), which then, in an iterative process, is tested against different parameters in order to develop the solution in a continuous process of change and optimization.

Therefore designing is a solution-based approach as a kind of "knowing and reflection in action" (SCHÖN 1987:158) – which is more similar to the probing, playful exploration of children than to the problem-based approach and controlled experiments by scientists. Designers shape a situation by putting things together through continuously evaluating the consequences of their actions, some initially known, some discovered through the process of designing. Therefore their creative exploration in order to find ways of changing the situation does not follow a systematic analysis and linear process, but finding the phenomena that designers seek to understand are part of the creative process. Drawing and sketching are the most important tools for supporting the designers' process of exploration and discovery, as they enable them to handle multiple alternatives and different levels of abstraction simultaneously. However designs can fail if the designer is limited to his own preconceptions and is unable to understand if and in what way his design decisions fail to achieve the intended results or produce unintended consequences.

Design thinking is on the one hand criticized as being subjective and unscientific while on the other hand it is acknowledged for producing solutions in complex settings, which are innovative and cannot derive only from analysis. CROSS (2007) states that scientists solve problems by analysis, while designers solve problems through synthesis.

2.3 Integration and synergies

GeoDesign can be considered a perfect framework to combine analytical systems thinking (analysis) and creative design thinking (synthesis), especially within large-scale and complex settings where the designers' intuition and ability to understand the preconditions and consequences of his ideas are put to a difficult test, e.g.: How much space for the flow of water is needed in order to prevent uncontrolled flooding? How many wind turbines or ha of solar panels are needed to enable the self-supply of renewable sources of energy within a certain area? In order to be able to evaluate, test and refine their initial ideas in complex settings, designers need new tools that support them to acquire an understanding of the implications of their design decisions. For many complex design tasks, sketching on tracing paper with a 2B pencil is just not enough to take informed decisions in the design process – and here the famous vision of Jack Dangermond (DANGERMOND/Esri 2009) comes in:

"Imagine if your initial design concept, scribbled on the back of a cocktail napkin, has the full power of GIS behind it". Tab. 1 summarises the different methodologies related to developing solutions and shows in what ways the different approaches in themselves are limited but what potentials they hold that could be combined in an integrated process.

Table 1: Methodologies, limitations and potentials of the two approaches

Approach	Methodology for developing solutions	Limitations and potentials
System thinking	Scientific, problem-focused strategy based on analysis: Identifying possible solutions by systematically analysing selected variables and parameters and exploring possible combinations in order to identify restrictions and potentials in a linear process.	In complex settings there are too many parameters to test and try all possible combinations in order to identify the best solution. However system thinking gives a very good understanding on the influence of different parameters and their interrelations on proposed solutions.
Design thinking	Creative, solution-focused strategy based on synthesis: Proposing and trying out solutions by changing a situation into a preferred one, exploring the implications of this change and adapting the proposed solution in a continuous loop, until the acceptable solution is found.	In complex settings the implications of a proposed solution cannot be fully grasped by the means of knowledge, intuition and sketching. However designing is a more effective way in terms of fairly quickly reaching a good or at least acceptable solution within a limited time and limited amount of information.

Based on their potential synergies, the two different approaches of analytical systems and creative design thinking can co-exist, go hand in hand and complement each other. In every stage of the Geodesign circle, the synthesis can build upon the results of a preceding analysis in order to get more and more refined. And every analysis can be linked to a subsequent synthesis in order to verify and correct its results. Integration of design thinking and systems thinking means to answer questions like:

- Which basic and significant landscape elements, structures and patterns are relevant for the design?
- Which processes of interaction, flow and change are influenced by the design?
- Do we have to expect complex, non-linear and unexpected dynamic behaviour caused by the design?
- Which potentials of resilience can be used or arranged by the design to avoid unwanted disturbance?
- Do we have considered long-term effects and sustainability?
- Is it possible to *quantify* all this?

2.4 Prototyping and toolbooks

Modular prototyping supports designers to develop ideas and scenarios on large-scale and complex sites in a non-linear working process and finally provides a modular system, which can be extended in further steps. Besides the advantage of having a time saving method to create large landscape visions the modules can be described more precisely, e.g., by ecological or, in general, system relevant parameters. For example, EISENBERG et al. (2014) identify different prototypical urban situations for the application of water-sensitive urban design strategies and their integration with the existing water infrastructure system in Lima, Perú (Fig. 1). They are parameterized by their specific topography, natural and man-made water sources, urban structure, water infrastructure system, and population density. They are representative for different urban landscape types and can be used to design a modularly combined spatial concept of green infrastructure, which combines a consistent water system with a multifunctional open space system. Figure 2 demonstrates how the current water cycle of each situation can be altered to become water sensitive, including a map which indictes the potential area for large-scale implementation in Metropolitan Lima and a design proposal to visualize possible measures.

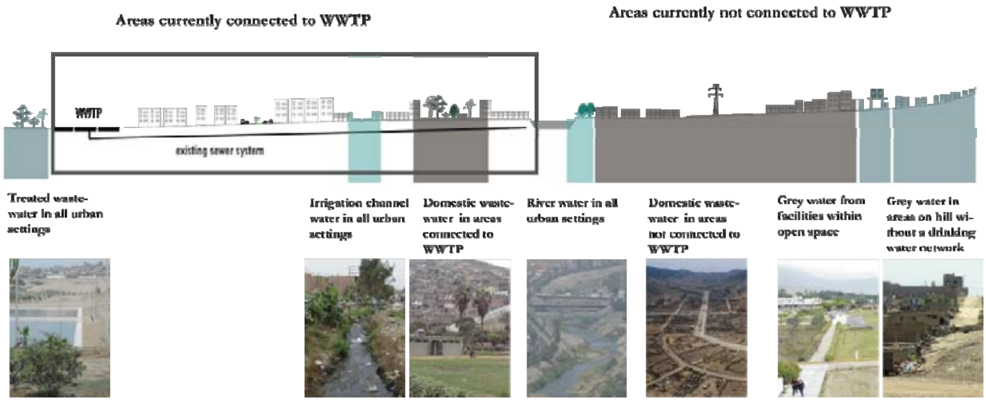

Fig. 1: Urban situations identified for application of water-sensitive urban design and their integration with the existing water infrastructure (EISENBERG et al. 2014).

Modular prototyping and derived toolbooks are "helpers", which support to combine system and design thinking. The first reason comes from the standardisation of inputs and output of urban spatial units. Module specific parameters indicate the module being appropriately implemented in regard to the requirements of the local situation as a place in the urban ecosystem.

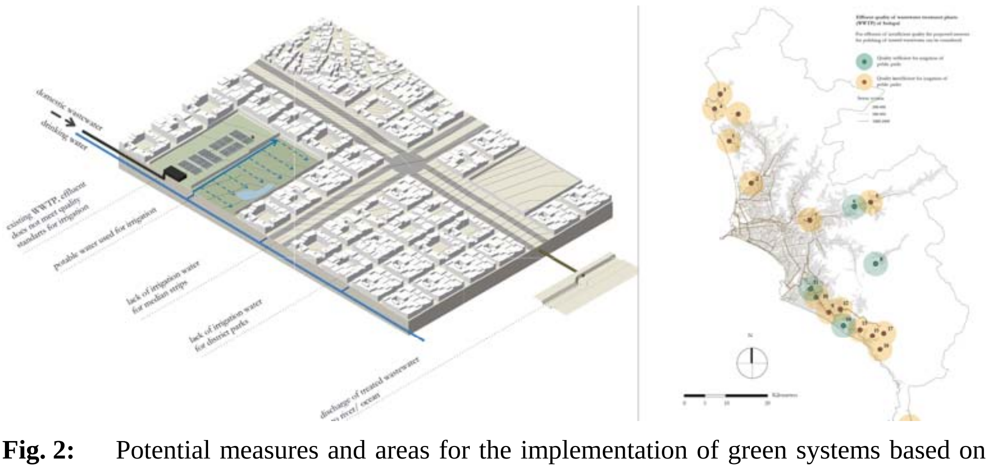

Fig. 2: Potential measures and areas for the implementation of green systems based on the irrigation with treated wastewater (EISENBERG et al. 2014).

3 Connecting Individual / Disciplinary Tasks and Interactive Teamwork

3.1 A Geodesign teamwork schedule

As mentioned in the introduction, at the core job level of Geodesign an iterative circle between geo-data mapping, sketching, GIS-analysis, simulation model runs and visual representation has to be installed. But this is not the only clue. A Geodesign project has to go through several preparatory steps of knowledge acquisition, exchange and provision. It has to include as an environment what STEINITZ (2012) labels as "people". A division of

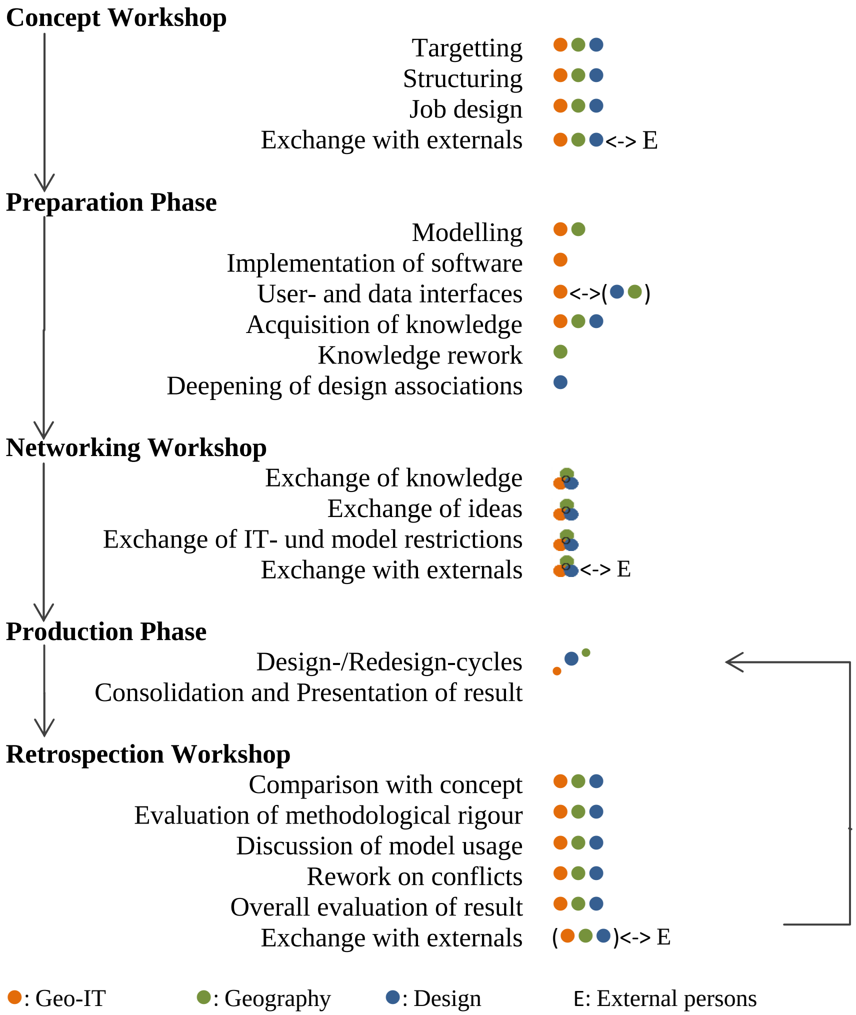

Fig. 3: Scheme, actors and activities in a Geodesign process (from SCHWARZ-V. RAUMER & STOKMAN 2013)

work between GeoIT/Geomatics engineers, Geography/Landscape Scientists and Planning/ Design experts has to be brought into a functioning team. We set high value on the collaboration process in Geodesign and suggest a workflow structure, which follows the chain of key elements: 'Concept workshop' – 'Preparation phase' – 'Network workshop' – 'Production phase' (as iterative core element) – 'Retrospection workshop' – 'Loop back' (SCHWARZ-V. RAUMER & STOKMAN 2013).

Figure 3 combines these elements and suggests a schedule for a GeoDesign process. The preparation phase has its kick-off in a concept workshop, which states the necessary steps and targeted outcomes of the preparations (IT infrastructure, landscape analysis, conceptual ideas), which are done individually by the different team members within the preparation phase. A "networking workshop" prepares the "production phase". The target of the workshop is to attain deep insights into relevant physical landscape structures and processes as well as in the local socio-economic and social-ecological framework. Secondly it brings up the designer's first conceptual ideas and introduces the available IT- and modelling facilities. And thirdly, the workshop introduces team-building necessities like target focusing, clarifying roles, team identity, interactions and potential conflicts. Both "concept workshop" and "networking workshop" include relevant external actors like clients, stakeholders or experts. When being well prepared by the previous steps the group dives into the "production" process, which repeats construction and reconstruction processes according to the GeoDesign-Cycle within a cooperative process between the different team members. Figure 3 illustrates the schedule.

3.2 Appreciation, Reflection and Flow

Focusing on the phases 'Networking workshop' and 'Production phase' certain personal and group necessities need to be considered for a successful Geodesign collaboration. Firstly the different roles in the collaborative process need to be clearly understood and defined by the participants. The precondition for productive teamwork is to achieve an attitude of esteeming und appreciative perception of different thinking and working modes, which means the anticipation of their different given capabilities and intentions in each partner's way of thinking and doing. This turns interaction towards a process which makes use of the benefits of working together, avoids destructive elements in communication and accelerates the progress of production. So in a Geodesign team, designers should be open for the restrictions coming from geo-scientific facts, model simplifications and the technical design environment. GeoIT / landscape specialists on the other hand need to be truly interested in the work of designers, in accepting and discussing their ideas and assisting to improve them. All team members need to feel confident with their specific role and ability while having interest in learning and working together towards a joint aim.

Secondly, the whole team needs adopt the perspective of personal learning through continuous loops of action, reflection and modification. The whole team should strive towards a fairly quick development of a practicable or even optimal solution within a given time limit – which does not enable to test all permissible combinations of different factors. A purely analytical approach often leads to suspending ideas and judgments until more is known, but a result which just states that "further research is needed" is not a justifiable conclusion in Geodesign. Therefore the overall approach should be design-based, which means that an initial understanding of the problem leads to different design ideas, which are tested and optimized against different parameters resulting from a thorough analysis in an iterative process. As a result, all team members should become, in the words of Donald Schön (SCHÖN 1987) "Reflective Practitioners" who continually improve their work „through a feedback loop of experience, learning and practice". Learning in loops – which should be also open to discuss targets and methods – is more or less the backbone of Geodesign and it should be the practiced by everybody who is involved in the collaboration.

And thirdly: For successful and satisfying outcomes together with *curiousness* – as a basic human driving force and as a precondition – *flow* is a clue. "Flow" as a psychological category was prominently described by CSIKSZENTMIHALYI (1990) who defined "flow" as being completely involved in an activity for its own sake.[1] If we consider Geodesign as a collaborative experiment based on creativity and iterative group flow, then clear and unambiguous communication, concentration and instantaneous "moving it forward" should be guaranteed – a big task for a group whose members come from different disciplines, have completely different skills and involve computers in a creative process.

4 Connecting Digital Computation and Analogue Techniques

Until now we have considered important *soft* skills for Geodesign: appreciation of different roles and skills, team dynamics and flow are necessary to enable collaboration and to overcome obstacles. This chapter however is about some hardware obstacles that Geodesign needs to tackle in terms of its use of digital data and computational tools to "instantly evaluate initial design sketches against a myriad of database layers" (DANGERMOND 2009).

4.1 Computation time, cost and evidence

From experiences when using models for decision support we know, that complex models are expensive both in regard to cost and computation time. Environmental impact modelling recommends us to use rough screening models first before deciding to use elaborated and more precise models. Screening models have to identify the significance of impact using a quick but – considering evidence – rough method. Doing this, screening models have to be pessimistic if we do not want to neglect impacts in cases they indeed are to be expected. Having the idea to use models in Geodesign and being keen on a very quick response of model computations (e.g., to keep the flow) this compensatory relation between

[1] CSIKSZENTMIHALYI (1990) states four important conditions for flow, when solving a task: the task must neither be too difficult nor too easy, secondly flow occurs when there is no doubt about the goal, thirdly there must be a constant and immediate feedback about the degree how close you are to achieving that goal and fourth it is necessary to be free to concentrate fully on the task. SAWYER (2007) picked up the preconditions of flow and did some research about flow in creatively collaborating teams. From this group genius (1) emerges incrementally and not by following a big picture, (2) needs deep listening and (3) acceptance of the collaborator's idea because (4) only when having evolved in further steps the meaning of ideas get clear. Successful work forward depends on concentration and equal participation and – this is crucial – on the acceptance that innovation is ineffective and "has as many misses as hits" (SAWYER 2007:16)

cost and evidence leads to the necessity either to costly enlarge modelling efforts and computation time or to accept a more or less huge bulk of uncertainty.

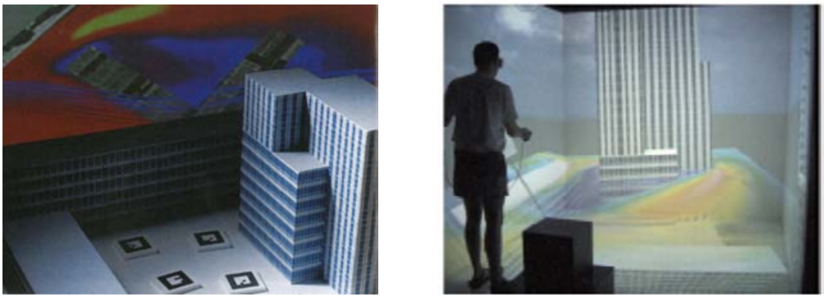

Fig. 4: Simulation of air flow in an urban skyscraper situation (right) configured on an interactive desk (left) (KIEFERLE & WÖSSNER 2003).

Let us study this considering a simple Geodesign configuration. Some housing blocks have to be located under control of ventilation to reduce negative impacts with regard to wind turbulence or thermal effects. A completely analogous Geodesign solution could be to hand over a draft to an urban climate expert who responds with a handmade sketch of a wind flow und turbulence map indicating benefit and conflict zones. You change your draft and the expert's comment evaluates your alterations. Both of you accept that knowledge, experience, and trust are a firm background for sufficient evidence. To improve evidence by providing computation results from a flow model you either simply have to wait or you have to use fast computing facilities in combination with a visualization technique which facilitates cognition of computation results. For example, as realized with an installation in the High performance Computing Center of University of Stuttgart (KIEFERLE &WÖSSNER 2003) which combines a high speed wind flow computation, its visualisation in a cave and a "design-desk" which allows an unrestricted configuration of a set of houses (Fig. 4). The installation implements a fully closed interactive Geodesign circle to get evidence for impacts – but it covers only a small aspect of urban design at high cost which can be roughly summed up to some ten thousands of Euros.

4.2 Sketching and information processing

The Geodesign circle consists of steps in information transmission and processing where computers, GIS and models help us. One of the most crucial steps is the process of *sketching* and its transfer to further processing. Here Dangermond´s dream of a draft made on a napkin being transferred into GIS still is a dream (DANGERMOND 2009). As stated in SCHWARZ-V.RAUMER & STOKMAN (2011), ArcSketch was a good start, but it should be improved not only with regard to usability but also linguistically. So at the moment we still have to represent spatial ideas reduced to points, lines and polygons, attributed by a table and drawn by a signature. This procedure is not only technically severely restricted, in addition it does not make use of the very fruitful marriage between creatively developing a spatial idea in your head and formulate it using an appropriate pen in your hand. In the design process, developing a sketch, which is firstly rough and gradually becoming more and more refined, is a very important way of developing ideas: The drawing, evolving from a rough sketch to a detailed technical plan, is the basic language of design and the tool for the reflective conversation with the site. To start the process with abstract, conceptual, interpretative drawings allows for interpretive synthesis. This ability is hindered severely if the designer is forced by the computer to be very precise very early in the process.

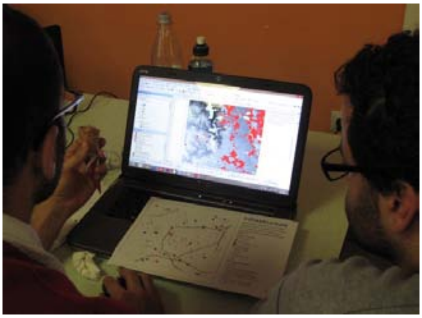

Fig. 5: Combining projections of GIS-results and manual sketching done by student during a Geodesign workshop.

Therefore we believe that *hybrid* techniques are needed, combining the advantages of traditional analogous design and the benefits of Geodata processing and representation. The best use of digital tools can be made if there is an anchor to the world we experience by head, heart *and* hand. With an illustrating example from a Geodesign student workshop we want to close this discussion for this article and hopefully open it for future developments. Fig. 5 shows how the team of GeoIT / Landscape Scientists (analytical approach) and Landscape Designers (creative approach) solved the problem of transferring basic geo-data maps as well as the result of suitability and energy gain calculations into the design: By installing a georeference system which could be used to transfer the displayed geo-information from a white board onto the transparent paper commonly used for drafting, the results could give a faster feedback about impacts and implications of their proposed designs than transferring the design sketches into the digital system.

5 Conclusions and Outlook

The “System of Geodesign” (ERVIN 2011) has to be considered in a broader sense: as a dynamic system of creativity which depends on the vital linkages between persons, between schools of thought and between Geo-IT and ideas. In our contribution we have emphasized, that there is a lot to be considered if we want to prevent “dead linkages”: difficulties in parallel design *and* system thinking, group dynamics and personal learning attitude, interrupts of group-flow, e.g., by computation time, or other threats for creativity decline, e.g., by being restricted from model application, IT-devices and time/cost efficiency. To improve our knowledge about such requirements of a functioning Geodesign process we need to carry out many experiments and workshops. And we have to discuss existing and to develop new appropriate targets, means and formats of training and education. This we will do with our students. But there is a different clientele in the game we have neglected until now and which is labelled by STEINITZ (2012) as “people”. At the moment we limit us to state, that to integrate technology, science and creativity *and* “people” affords to take a bulk of *additional* challenges – not only in regard to participative planning and design. Participative modelling as well as the inclusion of people’s knowledge must be ingredients of a participative Geodesign. Indeed enough material for an extra essay…

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