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Geodesign parsed: Placing it within the rubric of recognized design theories

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HIGHLIGHTS

- Geodesign process is compared with recognized design theories.
- Core components of geodesign are identified.
- A recommended Case Study Method for Geodesign is defined.

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ABSTRACT

It is neither the “design” portion nor the “geo” part that empower geodesign’s mode of practice and education—it is their combination that facilitates this model of land design and planning. One of the stated features and benefits of geodesign is that it brings together science and design. Inherent in that combining though appears to be the source of confusion. What distinguishes geodesign from design processes that deploy more innovative approaches to GIS? Is it geodesign if GIS workflows are used for decision support? There is a current lack of consistency in assigning the term “geodesign” to projects and practices. The author posits that geodesign engages GIS at several points in a design process including using GIS and relevant scientific data to better evaluate and understand the potential consequences of design alternatives. This article parses out the design portion to clarify what contributions design brings to the process. The intent is to situate the design aspect of geodesign within a lexicon of recognized design theories. The outcome of this analysis reveals core components that comprise a geodesign process. Those form the basis for a proposed Case Study Method in geodesign. A clearer understanding of geodesign as a new model of design practice emerges through this research by placing geodesign within the realm of other design theories and establishing critical dimensions in the form of a Case Study Method. The guidance provided by a Case Study Method approach to organizing and disseminating geodesign projects will help advance future discourse and practices.

1. Introduction

Its champions believe a prominent feature of geodesign is that it brings together science and design (Artz, 2010; Esri Press, 2012; Flaxman, 2010; Miller, 2012; Steinitz, 2012). In this case, the predominate science is geographic sciences, and in particular the science of geographic information systems (GIS) (Longley, Goodchild, Maguire, & Rhind, 2011). Many have suggested that science-based approaches can benefit from integration with creative approaches and the converse is most certainly true as well (Ahern, 1999; Alliance for the Arts in Research Universities). There is an increasing, renewed interest in the positive relationship between effective scientific ingenuity and nonscientific creativity (Root-Bernstein et al., 2008). A survey of recent publications and conference presentations about geodesign however reveal many instances in the emerging use of the term geodesign where either the science or the design are missing or not acknowledged (Davidson, 2014; Geodesign summits, 2012–2014). It appears many are enamored with the increasingly exciting digital and spatial tools, or showcase solid design projects, often very good works of landscape architecture but lacking a connection to science, and yet they seem to suggest that these are geodesign.

If its champions are correct, what distinguishes geodesign from similar processes? For example, geographic information systems (GIS) are frequently used to aid in making better decisions about sit-

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ing and location. Is this geodesign? Landscape architects have been using GIS as a component of their design process for years. Isn't this geodesign? This paper addresses this through a better understanding of both the commonalities and the differences between scientific and design processes in general. I argue for the importance of being vigilant regarding design's critical role as new practitioners and academics learn about and become engaged in geodesign. In particular, the recently published "Framework for Geodesign" by Steinitz (2012) is the subject of analysis and comparison with other design theories.

In this article I parse out and focus on clarifying the design portion of geodesign, to situate it within a lexicon of recognized design theories and in so doing, provide a format for assessing the degree to which projects embrace the characteristics of geodesign, and more clearly state how geodesign is both an old and new form of design practice – or more precisely – older practices enhanced and updated to form a new practice.

1.1. *Combining design and science*

The idea of bringing together the expertise of designers and scientists to address societal and environmental challenges is not new (Ahern, 1999; Foster, 2013; Lenzholzer, Duchhart, & Jusuck, 2013). In his 1998 book *Consilience*, respected scientist E.O. Wilson advocates that the most challenging issues facing humanity need to be addressed by integrating knowledge. "Neither science nor the arts can be complete without combining their separate strengths. Science needs the intuition and metaphorical power of the arts, and the arts need the fresh blood of science" (1998, p. 230). Ten years later, more germane to the focus of this article, the National Center for Geographic Information and Analysis (NCGIA) held a workshop which sought to investigate how GIS and design can become more fully integrated (Wilson, 2015). To better consider how this idea of disciplinary integration can work, it is beneficial to understand what design thinking and scientific inquiry have in common as well as how they differ.

Designers and scientists both seek answers through curiosity, however their means and outcomes are different. Design is interested in discovering new opportunities of how things can be, whereas science is interested in a better understanding of how things are (Fast Company, 2006; Simon, 1969). To accomplish their aims, both design and science utilize analysis and synthesis. Design and science also have in common the products of their efforts: concepts; however these are not the same type of concepts. Designers produce alternative concepts for how to transform existing conditions into desired ones (Simon, 1969), and scientists produce one or more alternative hypothesis about the situation (Asimow, 1962). Both science and design begin with abstraction but the trajectory of their efforts lead to a different end state. Design's goal is typically a specific answer – it is not broadly applicable – whereas science is just the opposite, seeking a class of answers which is generalizable. Design can only function in the presence of distinct constraints that will lead to a concrete resolution; science however works towards objectively measurable phenomena and universal knowledge (Asimow, 1962; Brown, 2009; Lenzholzer, 2013; Rowe, 1991), and in the social sciences, the democratization of knowledge (Berg, Lune, & Lune, 2004). Understanding commonalities as well as differences can benefit the process and help promote productive working relationships amongst scientists and designers (Foster, 2013). An important example of the complex, coupled relationship between design and science can be found in landscape architecture's "empirical research" approach where design is seen to "include the translation of specialist knowledge (e.g. hydrology, climatology, landscape ecology or environmental psychology) into . . . design guidelines or other models" (Lenzholzer, 2013, p. 122).

GIS has its origins largely (but not exclusively) in design at the Harvard Graduate School of Design but is now a well-respected and multifaceted science (Longley et al., 2011; Wilson, 2015). Bill Miller, Director of Geodesign at Esri, a leading GIS software company, states that geodesign is the third stage in the evolution of Geographic Information Systems.

> "There are three major segments of GIS evolution and technologies . . .. (The first) is data, with maps that bind, secure and use data. Esri started out developing geodatabases, and the big question was, "where's the data?" As that mission was fulfilled, it migrated to the second segment, (which is). . . analysis and feature processing – you analyze geography for various purposes and reasons. The third segment is design, and that's the most recent segment. Once you have data and you analyze it for a purpose, then you do creative work with that analysis." (Ball, 2012)

Recent definitions (Canfield & Steinitz, 2014; McElvaney, 2013) expound on to this by incorporating impact simulations and real-time feedback, which means that science and data contributions also play a role post-design scenario generation. In other words, geospatial technologies are reengaged to better evaluate and understand the potential consequences of those creative ideas. Miller's concise statement supplemented by recent definitions of geodesign illustrates that science and data are integrated with design as part of the geodesign process.

2. How is geodesign design?

> "Geodesign is a vision for using geographic knowledge to actively and thoughtfully design." Jack Dangermond (2012, as cited in Steinitz, 2012, Foreword)

> "Geodesign is a method which tightly couples the creation of design proposals with impacts simulations informed by geographic contexts and systems thinking and supported by digital technology." Michael Flaxman (2010)

> "Geodesign is an iterative design method that uses stakeholder input, geospatial modeling, impact simulations, and real-time feedback to facilitate holistic designs and smart decisions." Shannon McElvaney (2013)

> "Geodesign is design in geographic space." Bill Miller (2010, as cited in Steinitz, 2012, xi)

These are commonly cited statements that describe and define geodesign. Every statement provides an indication regarding the role for design. Interestingly, these definitions do not emphasize GIS specifically; only McElvaney's "geospatial modeling" comes close (2013). The references to design in all statements make it clear that the inclusion of design-thinking or design processes is central to geodesign. There are countless ways that design is defined, and it is both a noun and a verb. For this article the verb definition applies. A compiled definition I will use for design is: A purposeful process to solve a problem, involving creativity and skill. Design is a process that changes need and purpose into a solution (Asimow, 1962; Fast Company, 2006; Merriam-Webster; Simon, 1969).

Simon's statement captures the approach taken here to better articulate the design process:

"When we study the process of design we discover that design is problem solving. If you have a basic theory of problem solving then you are well on your way to a theory of Design" (Simon, 1995, as cited in Hatchuel, 2001, p. 263). There are many models of problem solving as well as many design theories. As defined above, design involves creativity, so the investigation is further narrowed to focus on creative problem solving.

Table 1
Creative problem solving processes; design processes.

	Simon (1977, 1997)[*a]	Asimow (1962)	Fogler and LeBlanc (1995)	Brown (2009)[*c]	Kumar (2012)	Steinitz (2012)
Stage 1	Intelligence	Analysis	Define	Inspiration	Sense Intent Know Context Know People	Pass 1 "Why": Understand study area
Stage 2	Design	Synthesis	Generate	Ideation	Frame Insights Explore Concepts	Pass 2 "How": Specify Methods
Stage 3	Choice	Evaluation Decision [#b] Optimization [#b] Revision [#b] Implement	Decide Implement Evaluate	Implementation	Frame Solutions Realize Offerings	Pass 3: "What, Where, When": Perform Study

[*a] First published in 1947 and 1960.
[#b] Asimov states the addition of these three realms distinguishes the design process from general problem solving (1962, p. 44).
[*c] Three constraints: desirability, viability, feasibility, are to be considered at every stage (Brown, 2009, p. 19).

2.1. Creative problem solving and design theories

Steinitz's "Framework for Geodesign" (2012) is the subject of analysis for this article. This recently published framework is selected as representative of the geodesign process because Steinitz is widely recognized as one of the originators of geodesign (Wilson, 2015). His framework specifies a very detailed process devised based on decades of research and application. To juxtapose this framework with other design theories and creative problem solving processes, its key components are compared to five frameworks or theories, a cross-section of which were selected based on their renowned contributions to the field or the author's recognized expertise on this topic. It is acknowledged that there are a wide variety of ways that design has been interpreted and represented in the past half-century (Cross, 2007). This group is representative of the variety of the main approaches recognized in the field of design theories.

Herbert Simon, who wrote over 800 publications and is extensively cited, won a Nobel prize for pioneering research in decision-making processes. Although his work is not specific to creative problem solving, he developed his theory primarily with engineers in mind, therefore much of his research can be regarded as a theoretical foundation for later theories on design processes (Pomerol & Adam, 2004). Morris Asimow's book *Introduction to Design* (1962) is one of the first books written about design methods (Cross, 2007). H. Scott Fogler and Steven LeBlanc received the Meriam/Wiley distinguished author award from the American Society of Engineering Education for their 1995 book *Strategies for Creative Problem Solving*. The book has been cited in nearly 180 publications. Tim Brown is CEO and president of the internationally recognized design firm IDEO. His 2009 book, *Change by Design: How design thinking transforms organizations and inspires innovation*, has been very influential, especially for non-designers. Vijay Kumar is a professor at the Illinois Institute of Technology's Institute of Design and leads the Strategic Design Planning and the Design Methods programs. His recent book, *101 Design Methods* (2012), compiles 30 years of research into a design innovation planning process.

The six frameworks or processes each have between three to seven main components. Most all design processes are considered to be iterative and non-linear. The processes have parts that loop back on themselves at various points; it is therefore better to think of the design process components as "overlapping spaces rather than a sequence of orderly steps" (Brown, 2009, p. 16). A distinct difficulty is how best to represent processes that are non-linear in a way that makes comparison possible. Table 1 shows the main components of each of the six processes in their "ideal" sequence from start to completion of the process.

Three of the six (Simon, Brown, Steinitz) have three main components to the overall process, while the other three, with the exception of Asimow's later stages, are in general agreement with this tri-part portioning of the process, albeit with further subdivision within some topics. Due to this variation in process structure, to avoid confusion, the three main components of the process will be referred to as Stage 1, Stage 2 and Stage 3, shown in the left column of Table 1. Steinitz in particular is challenging to illustrate as the "three iterations" of his framework each contain six parts, which he calls "models," see Fig. 1 (2012, p. 25). One could argue that his framework should be represented by 18 parts. Without including all 18 parts in the table, I will seek to explain the details of those subdivisions as all six design processes are compared. All the processes studied, and in particular the innovative design process as outlined by Kumar, share with Steinitz's process, a structured framework that enables iteration and fluidity without sacrificing organization.

2.2. Comparison of Stage 1 of the design process

It is interesting to note that each of the six design processes use a different term for the first phase of the process. Following from Simon on the left through to Steinitz on the right in Table 1: Intelligence, Analysis, Define, Inspiration, Sense Intent, Understand the study area. These terms are similar, so perhaps it is not surprising to find strong agreement among all six theories as to the role and value of the first stage in the design process. All provide clear articulation that a thorough understanding of the problem is key to the future success of the process. For example, Fogler and LeBlanc include a technique titled "Present State/Desired State" (1995). The Present State outlines the problems and needs. ". . .the Desired State should not contain solutions to problems that are not in the Present State. . . . Reworking the Present State and Desired State statements until they match is a technique that increases the probability of arriving at the true problem statement" (1995, p. 41). An example of the importance of knowing the constraints at the onset is well expressed by Brown: "The willing . . . acceptance of competing constraints is the foundation of design thinking. The first stage of a design process is often about discovering which constraints are important and establishing a framework for evaluating them" (2009, p. 18). Simon says that the process will need a "steering mechanism" to know where to search as well as "satisficing criteria" to know when to stop searching (1969, p. 71). This too is referring to the need to know the problem constraints as well what requirements will constitute a satisfactory solution. Steinitz states that the role of the first-pass through his framework process is to establish the most significant decision-making criteria, including the priorities and requirements (2012). The sub-parts of his framework for this stage include the need to clarify the physical extent, how stake-

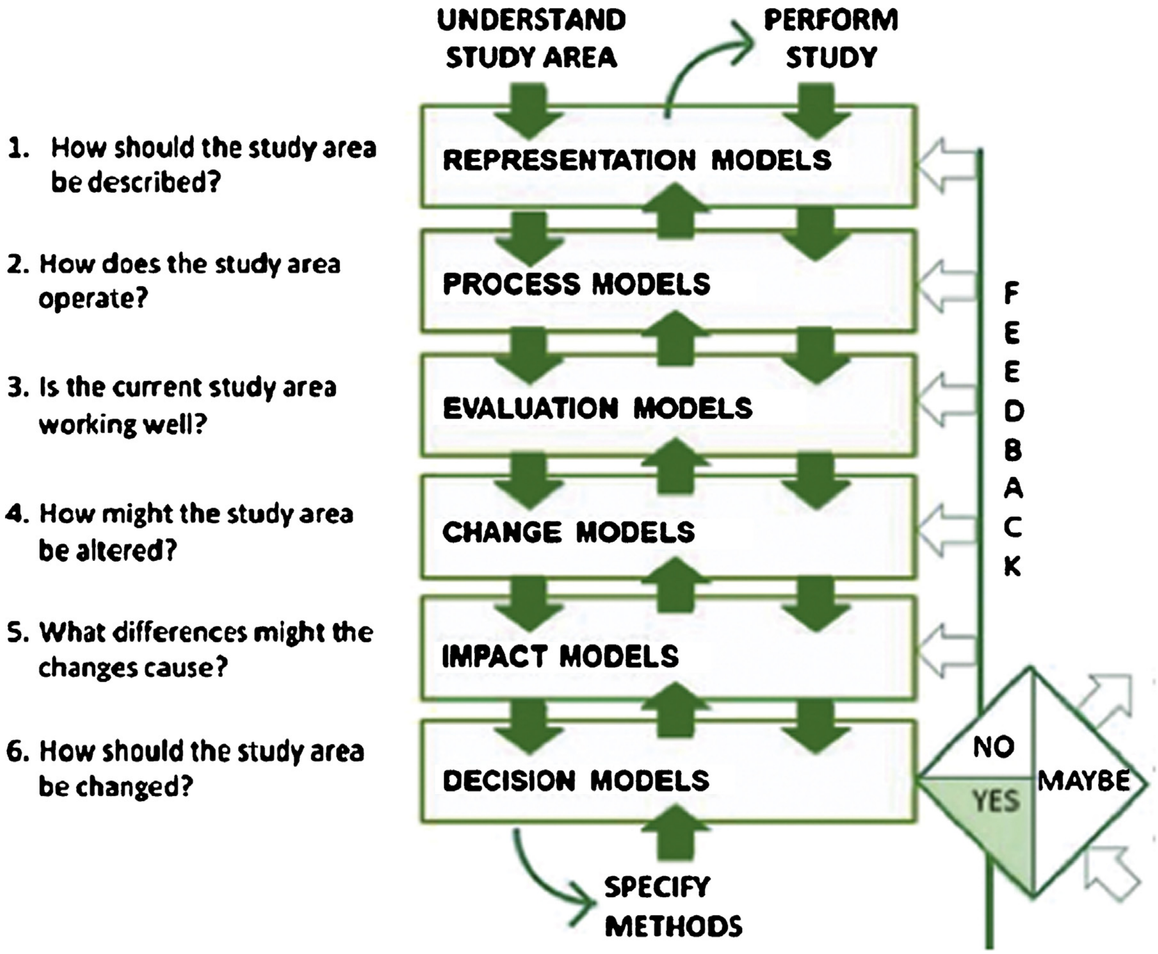

Fig. 1. Carl Steinitz's "Framework for Geodesign" process structure.

holders regard the prospect of change, as well as what is working and not working, which he calls cultural knowledge (Steinitz, 2012). Kumar has three parts that correspond to the other processes' Stage 1. Kumar calls these "modes" and way he describes them provides a nearly perfect alignment with Steinitz's framework. These are "Sense Intent," "Know Context," and "Know People" (2012, p. 10).

Steinitz is very explicit that the process must be decision-driven, therefore understanding who will make decisions about the outcomes, and their decision-making process, is shown as the last model (Fig. 1), and is central to this first stage of his framework (2012). Asimow also emphasizes the critical role of decision-making through all phases of the design process (Rowe, 1991). Simon's life's work was rooted in the importance of the decision-making process and he contends that most processes err in not realizing the importance of having the decision makers as "actors" in the process (Kalantari, 2010, p. 513). Simon argues that decision makers are focused on their self-interests, therefore learning their goals will not only give them an active role, but it will aid in framing the issues of prime importance to the people who will determine the outcome (Kalantari, 2010).

This comparison finds a strong consensus as to the key components of the first stage of a design process. These are (a) develop a detailed understanding of the problem, including the constraints, (b) engage users or stakeholders in coming to that understanding, (c) come to an agreement about the desired end state or intent, and (d) articulate criteria that will be factors in how decision makers determine a choice at the conclusion of the process. The process being studied, Steinitz's Geodesign Framework (2012), is in agreement with these. It is important to recall here that these are generalized "stages" which are not linear or sequential in their actual application during the design process.

2.3. *Comparison of Stage 2 of the design process*

For Stage 2, all six processes being studied in this comparison express some sort of activity related to "designing" as part of this stage, but the interpretation of that, and what is involved, varies. The terminology each use's as a label for this stage illustrates both the similarities and the variety; from Simon on the left through to Steinitz on the right in Table 1: Design, Synthesis, Generate, Ideation, Frame Insights & Explore Concepts, Specify models.

Brown says the second of his "overlapping spaces" is ideation, where ideas are generated, developed and tested (2009, p. 16). He discusses this as a process of synthesizing the insights from Stage 1 (Brown, 2009). Giving order to insights, generating ideas and synthesizing the information, corresponds, in order, to how Kumar, Fogler and LeBlanc, and Asimow articulate Stage 2. Simon states that design "means synthesis;" it is the conceiving of ways to accomplish goals (Simon, 1997, p. 246).

A unique distinction for Stage 2 of Steinitz's process is that he establishes, in detail, "how" to perform the design process, which he executes in Stage 3 (2012); whereas others at Stage 2 are engaging in design, such as generating solutions (Fogler & LeBlanc, 1995). To be sure, Steinitz is also engaging in design but not in the traditional sense. It can be said that in Stage 2 Steinitz is setting up "the design of the design" (Shearer, 2012, p. 192), through specifying each of his framework's six models, in a specific order, such as the change model, evaluation model, and so on (see Fig. 1). This is a unique feature of his framework because each model is "interrelated . . . Each . . . informs the substance and significance of the others, ... consistent and coherent judgment emerges as separate assumptions come into alignment" (Shearer, 2012, p. 190).

Because of the finer-grain detail present in how Kumar explains his process, it is possible to see some alignment between his Design Innovation Process and Steinitz's Framework for Geodesign. Kumar's "Mode 4: Frame Insights" is where Stage 1 information is translated into guidelines for concept generation (Kumar, 2012, p. 11). In a general way, this is what Steinitz is doing with the specificity of models—those models become the guide to doing the design. Both Kumar ("Mode 5: Frame Solutions"), and Steinitz ("Perform Study") separate design execution from the development of design guidance.

Another interesting alignment in Stage 2 is between Simon and Steinitz regarding when data should be acquired. Simon says to "gather information about what follows from what was proposed or assumed" (1995, p. 247). Steinitz waits until the last step in Stage 2, "Representations Models," to articulate how the study area should be described. This is the step where information is gathered. Steinitz stresses the importance of assembling only what is necessary; "to identify the minimum amount of data actually needed for the study" (2012, p. 73).

There is general agreement among the design processes studied that the information discovered in Stage 1 is to be influential in the development of design solutions. This is therefore a key component of Stage 2. A difference emerges regarding how much effort is placed on understanding the information and using it to form guidance before venturing into the actual design activity. Steinitz, and to a lesser degree, Kumar, are more deliberate in how they approach getting to the actual design execution. The details of Steinitz's interrelated models and the design structure that emerge from using his process reveals how his geodesign framework is an enhancement of previous design processes.

2.4. Comparison of Stage 3 of the design process

The last stage of the design process, Stage 3, is similar to Stage 2 as there are both commonalities as well as differences among the six processes compared for this article. Table 1 shows a greater variety in the number of sub-parts and their "sequence" at this stage, though being mindful that this is not a linear process. It is interesting to note that once again, each process uses related but different terms in the names for this stage. In Table 1, from Simon on the left through to Steinitz on the right: Choice, Evaluation and Decision, Decide, Ideation, Frame Solutions, Perform Study. The outlier in that list is Brown's Ideation, which in Table 1I show as part of both Stage 2 and 3. He describes the ideation stage as including a "divergent process of creating choices" and the necessity to move to the "convergent phase of making choices" (Brown, 2009, p. 82).

There is a fair bit of agreement among all the processes as to how decisions are made to select the best alternative from among the choices generated in Stage 2. For example, Fogler and LeBlanc use "decision analysis" to assign weights and scores for the objectives to better understand the consequences (1995, p. 103). Simon and Steinitz add to this emphasizing the importance of clearly specifying criteria and considering the most restrictive first (Simon, 1997; Steinitz, 2012). Another outlier might appear to be Fogler and LeBlanc's "Evaluate" at the end (see Table 1), which is a final check on quality of the chosen solution; however they explain that evaluation is also an ongoing process, assisting at each phase to ensure goals are satisfied (1995). This reinforces the principle that design processes are iterative. The importance of frequent evaluation, often called "re-evaluation" or "feedback," throughout the process is shared by several of the design processes. Fogler and LeBlanc's final "Evaluate" equates to Asimow's "Optimization" and to Steinitz's "Yes/No/Maybe" determination (see lower right of Fig. 1).

Four of the design processes studied are explicit in placing significance on satisfying the end user or stakeholder at this concluding stage of the process. Kumar speaks of "evaluat(ing) concepts (to) identify the ones that bring the most value to stakeholders" (2012, p. 12). For Asimov the "level of confidence" the stakeholders have in a solution is key to how decisions are made. Confidence is built based on how well stakeholders understand evidence and how it addresses their needs (Asimow, 1962). Brown advocates using storytelling as a way to connect with the audience in a manner that will relate to them and help them form their own conclusions (2009). Kumar also includes a role for narratives in helping to frame solutions for the user (2012). The last model in Steinitz's third pass through the framework is "Decision Models" (see Fig. 1). Throughout his book, Steinitz is clear that those making decisions are the end users or "people of the place," and not the designer (2012).

Simon elevates choice as a main component of design. He believes there is a typical pattern for how choices are made: a project has previously identified constraints, as well as objectives, which are then used as factors to weigh the merit of each choice by how well it achieves the project's goal. This corresponds to the other design processes regarding the role of choice. He further discusses that making choices can be assisted by tools (Simon, 1997). Simon believes that decision makers need assistance in this process and he suggests that other disciplines could develop intelligent systems, which he calls "artificial intelligence," to enable decision making to be much more effective (Kalantari, 2010, p. 518). Simon uses the word artificial to mean "man-made" (Simon, 1969, p. 4). I believe that Simon would agree that GIS systems meet his definition of artificial intelligence. A discussion about the role of digital technologies is provided below.

As mentioned above, this stage provides the least clarity in how best to "categorize" each design processes' "steps." Along with Brown's "Ideation" irregularity, discussed above, four of the six design processes include indication of application or execution of the design: "Implement," "Implementation", Realize Offerings," and "Perform Study" (Table 1, left to right: Fogler and LeBlanc, Brown, Kumar, Steinitz). As an example, Brown's Implementation at Stage 3 is when "the best ideas are developed into concrete, fully conceived plan of action" (2009, p. 64). Kumar similarly states that the role of his seventh mode "Realize offerings" is "to explore how our ideas might take form in the real world and be successful" (2012, p. 285).

All the design processes described essentially agree with Brown's articulation that this stage is a convergent process aimed at identifying preferred alternatives. There is also general agreement that some system of weighting, ranking, and/or scoring is used to help narrow the choices. A majority of the design processes place strong value on recognizing end users' or stakeholders' needs and desires as important factors in both narrowing choices and helping the decision-makers have confidence in the final selection.

Those who regularly partake in design processes will recognize Steinitz's third pass through the geodesign frame as a typical design sequence; however they would be mistaken to think it is what they are familiar with. An important distinction is that Steinitz's cues up this process through careful orchestration during the previous stage to ensure the process is rooted in stakeholders' needs and desires, as it is those individuals who are charged with making decisions about the suitability of the design options (Shearer, 2012).

3. Role of digital technologies

The use of computational tools and technology, particularly their connection to scientific data, is increasingly important to the geodesign process. In Canfield & Steinitz's definition, they stress that geodesign is a process, and acknowledge at the end that it is "usually supported by digital technology":

> "Geodesign applies systems thinking to the creation of proposals for change and impact simulations in their geographic contexts, usually supported by digital technology" (Canfield & Steinitz, 2014).

The role of digital tools and its connection to geodesign is important to clarify as often times the technology by itself is portrayed as geodesign (Davidson, 2014; Geodesign summits, 2012–2014). In the overview of the design process, the importance of selecting criteria, organizing the project details, acquiring data and developing ways to communicate ideas to stakeholders is readily apparent. While Steinitz has demonstrated many times over decades of deploying his Geodesign framework that it can work without digital technology, in today's world, with easy digital access to so much valuable information – in particular scientific data – the majority of geodesign processes will engage this technology. As Stephen Ervin, one of the champions of geodesign, asserts, digital space is where the creative process, data and science, and graphic representations can truly come together for a positive impact on the process. "There was no geodesign 50 years ago. Now we have computers, software, satellites, collaboration tools, apps, and smartphones—we have a whole new discipline on our hands" (Esri Press, 2012). E.O. Wilson emphasizes that both the arts and science seek patterns as a way to make sense of complicated and confusing information (1998). The creative part of the process is the search for opportunities related to current conditions and constraints and the desired future. An important component for this part of the process is recognizing patterns (Downes, 2006). Asimow points out that a distinction between design processes and general problem-solving is the use of "sharper . . . and more analytical tools" (1962, p. 44). GIS provides this bridge between design and science as it is a tool, and a language, of spatial thinking that can greatly assist in pattern recognition (Goodchild, 2013).

Simon saw the value of computing power for assisting the design process. He understood that for complex projects, the human mind has limits on comprehension capabilities. "Repeated applications of this recognition mechanism can guarantee that the final design product will be responsive to a vast range of considerations that couldn't possibly have been held in attention simultaneously" (1995, p. 250). Along with digital technologies as a dynamic way to manage and illuminate information, Brown adds that technologies provide rapid generation of alternatives (2009). Coupling that with the rapid evaluation of those alternatives is the "real-time feedback" McElvaney includes in his definition of geodesign (2013). Flaxman posits that professional divisions often end up separating design from evaluation: how do you know if what you designed truly is, for example, a green neighborhood? (2010). The ability to generate a variety of possible design solutions quickly, and then rapidly evaluate them against their success in achieving desired goals, is a great strength of combining geospatial technology with the design process. The ever-evolving capabilities of desktop and cloud-based geospatial tools for modeling, scenario generation and evaluation, and producing engaging communication, provide potentially transformative opportunities for how the geodesign process can advance.

4. Collaboration and teams

Design is rarely a solo act of genius. This is especially true when the design task is a multi-faceted, complex land-based challenge. Brown clarifies the need is more than simply operating in a multidisciplinary approach, rather what is needed is an interdisciplinary perspective: "In an interdisciplinary team there is a collective ownership of ideas and everybody takes responsibility for them" (2009, p. 28). He calls these "smart teams" (Brown, 2009, p. 26). Simon recognizes this too, discussing the importance of establishing a foundational base for "intellectual endeavor and communication across the arts, sciences and technology" (Cross, 2007, p. 54). Kumar and Steinitz also share this view, using the word "collaborative" and suggesting that for a successful process it must value the input of people with expertise in different fields and including community stakeholders and the decision makers (Kumar, 2012; Steinitz, 2012). Planner Paul Zwick (2010, p. 10) specifies one of his criteria for geodesign is that the process "integrate the design professions with other disciplines—ecology, geography and other earth sciences, real estate, and the social sciences".

5. Summary findings

Carl Steinitz's "Framework for Geodesign" (2012) is the subject of a detailed review and analysis to ascertain how well his prescribed approach compares with five other recognized design processes. Among the six there is remarkable similarity in the roughly defined "stages" of the process as well as a common understanding that design processes do not proceed in a straightforward, linear fashion. All state the importance of clearly articulating the project goal, from the onset of the process. Four of the design processes, including Steinitz (2012), place emphasis on the goal being decision- or stakeholder-driven, and that it must remain front and center throughout the process; in fact Kumar uses a graphic whose configuration reinforces the non-linear nature of the process by placing the first stage, "Sense Intent," directly in the center (2012, p. 8).

The six processes analyzed all go through a variation of a "divergent" process, aimed at gathering relevant information to inform the process, and using that to generate ideas. They then proceed into a "convergent" process where weighting and evaluation translates the information and ideas into potential solutions. Several of the processes then have a further evaluative step that assesses the solutions' performance based on the original project goals. Steinitz is among the majority of the design processes that place high value on recognizing end users' or stakeholders' needs and desires as key criteria in narrowing choices, which is seen to help stakeholders and decision-makers have confidence in the final design selection.

Although Steinitz's design process – his framework for geodesign (see Fig. 1) – aligns quite well with the majority of the design processes studied, he does differ from the others with a unique twist to the method: his series of "models" are actually a progression of interrelated questions. The responses to those inform the next model/question and this layering results in a well-informed, rooted-in-the-true-problem solution (Shearer, 2012). This unique structure to the design is an enrichment over the other design processes analyzed in the paper.

Another finding points to a valuable role for digital technology in the process and particularly for assisting in evaluating design alternatives against desired performance criteria. Digital, spatial technology also plays an essential connector-role in fostering dialog and understanding between the process participants: designers, scientists and the community. Though Steinitz discusses how his process operates in both analog and digital realms, his definition of geodesign says "usually supported by digital technology" (Canfield & Steinitz, 2014) and certainly the models portion of his process, especially the "Impact Models," is greatly enhanced by the use of rapid-feedback geospatial analytic tools.

The participation aspect of the design process presents a final key finding. Steinitz is among the majority, and one of the strongest advocates, regarding the importance of including multiple voices and perspectives during the design process. Though technology is valuable, it should not be used at the expense of stakeholder understanding and engagement (Steinitz, 2013).

These findings provide supporting evidence that geodesign, as specified by Steinitz (2012), is a process that incorporates design and aligns with other recognized design processes. Geodesign operates in an interdisciplinary manner and is enriched by digital technology. This coupling of science and geospatial technology with the geodesign process, particularly Steinitz's framework which provides detailed instructions for "designing the design" with the decision makers in mind, clearly demonstrates that this is an enhancement to design approaches that results in a new model for design practice and education. The key findings from this structural analysis of the design processes provide the foundation for the proposed Geodesign Case Study Method, discussed below in Section 6.2.

6. Establishing a geodesign case study method

6.1. Value of case study method

A significant question surrounding geodesign since the term was coined several years ago is "what is geodesign"? This article adds clarity to this through evidence that situates geodesign within the realm of design processes, highlighting both commonalities and unique aspects. What remains is to identify a mechanism to formalize this understanding and therefore provide a structure to begin to establish a record of geodesign work, which will aid in advancing the field and framing the "development of new knowledge" (Francis, 2001, p. 15). Wilson also addresses the need for "'new' geospatial scholarship" that supports the combining of design and "geospatial technoscience" (Wilson, 2015, p. 5).

The case study method of investigation and documentation has been commonly used in community planning (Yin, 2009). It is appropriate to use in situations that are "technically distinctive," and based in real-life, contemporary contexts that consider evidence and input from multiple sources (Yin, 2009, p. 18). The case study method provides an approach that preserves the holistic and significant characteristics of actual events, such as the prevailing processes used, the community issues and features, and group activities and behaviors (Yin, 2009). In particular, explanatory type case studies are well suited for use when dealing with a series of "operations" linked over time (Yin, 2009, p. 9). The geodesign process, as articulated in this article, falls within all of these stipulations.

Mark Francis outlined a suggested explanatory type case study method for landscape architecture, with the goal to "improve the level of practice and scholarship in landscape architecture" (2001, p. 15). Other researchers have completed work based on this method (Ahern, 2002; Erickson, 2012; Schneider, 2003), and the Landscape Architecture Foundation (LAF) used this as a basis to define the "CSI" (Case Study Investigation) approach (no date). Due to these published examples and LAF's experience implementing the CSI studies and the similarities between landscape architecture design practices and geodesign, the CSI method serves as a sound basis from which to consider formulating a structure for a geodesign case study method.

6.2. Suggested geodesign case study format

Similar to the "Critical Dimensions" that provide the basis for the landscape architecture case studies outlined by Francis (2001), a rubric is delineated here based on the core components of the geodesign process, summarized above. The eight core components serve as criteria to gauge the effectiveness of a geodesign process. Due to variability inherent in design and the complexity of each land design and planning challenge, exact "matches" of case study projects to the core components is not the goal. Rather, projects that exhibit a general agreement with, or contain a high percentage of, the core components can be recognized as possessing key characteristics of geodesign. The proposed Geodesign Case Study Method establishes a basis for qualitative research by providing a consistent organizational and recording structure. The information requested for each of the eight core components will aid in securing the credibility, confirmability and authenticity deemed essential for qualitative research. Additionally, as case studies accumulate and this body of knowledge grows, the other essential aspect of qualitative research, transferability, will also be enabled (Guba & Lincoln, 1994). Four of the seven LAF CSI components are related to the key findings from the design process analysis and are therefore relevant to include in the Geodesign Case Study Method: Overview, Challenge, Solution, Lessons Learned. The two of the remaining three LAF CSI components do not align as well, Sustainable Features and Cost Comparison. The seventh of the LAF/CSI components, "benefits," can be revised to be specific to geodesign case studies. To ensure the Geodesign Case Study Method covers all of this study's key finding's core components, three additional components are included due to their distinction for geodesign: collaborators, process details and the role of technology. Table 2 shows a side-by-side listing of the LAF CSI and proposed Geodesign Case Study Method components.

Table 2
Case study method components.

LAF/CSI (no date)	Geodesign
Overview	Overview
Landscape Performance Benefits	Geodesign Process Benefits
Challenge	Challenge
Solution	Solution
Sustainable Features	Collaborators/Participants
Cost Comparison	Process Details
	Role of Technology
Lessons Learned	Lessons Learned

Following the recognized format of the LAF CSI, the Case Study Method has two sections. A Project Synopsis is the first part of a Case Study's documentation. Basic details common to all projects are recorded in a "General Project Information Synopsis," which includes project name, location, date, client, budget, scale, land use, project type, and lead consultants (LAF, no date). The second part of the Case Study's documentation contains descriptions about the case study components. It is important to note that this follows Yin's "explanatory type case studies," which are appropriate for recording actual events that deal with a series of "operations" over time (2009, p. 9). Below is a listing of what is to be included in the descriptions for each of the proposed eight components for the Geodesign Case Study Method. The four in common with the LAF/CSI are worded similarly but incorporate language specific to this study's key findings. The four additional components draw directly from the core components of geodesign identified above.

Describe the eight core geodesign case study components

Overview: describe why the project is significant and relevant to geodesign.

Benefits: explain the community, environmental, and related enhancements and/or changes realized though engagement in the geodesign process.

Challenge: identify unique constraints or opportunities; describe any key regulatory, design, environmental, scientific or technical issues the project had to address. This section should directly relate to the "Solution" section.

Solution: explain the project outcome in terms of satisfying the stakeholder/community goals, and key practices or strategies used to address the challenges and achieve the project goals.

Collaborators/Participants: discuss the role and contributions of all participants, including design professionals, scientists, domain experts, and the community. Explain how this was a collaborative, interdisciplinary effort.

Process Details: as a fundamentally decision-driven process, illustrate the project process used, highlighting how it is structured to work with interrelated phases or models and incorporates stakeholders' needs and desires. Discuss how the process included scientific expertise and/or data.

Role of Technology: describe the technologies used, including any analog techniques, such as citizen's notations on printed maps, and digital tools, such as geospatial modeling or computer simulations, and their role in facilitating the process.

Lessons Learned: outline any insights gained, particularly those which could be influential for future projects and processes. What worked and didn't work? Were tradeoffs made? What could have been done differently to make the project more efficient or effective?

Francis called for "comparative methodologies" and case studies on different topics (2001, p. 27). The close alignment that geodesign and landscape architecture share and the proposed similarities in these two case study methods will enable the possibility of future research opportunities to analyze and compare project characteristics, processes, outcomes and the like. The proposed geodesign case study method can be used to analyze any design and planning project and determine to what degree it includes key components of a geodesign process. A further aim of this case study method is to have its use inform teaching, research and professional practice, all in the spirit of advancing the ongoing development of geodesign. As the collection of geodesign case studies grows, they will serve as resources for teaching and as guidance and source inspiration for new research directions. The critical dimensions of the case study method's core components provide practitioners with guidance in organizing a geodesign project from the onset.

7. Conclusion

This article set out to clarify what distinguishes geodesign from similar processes and to establish a format for the assessment of design processes purporting to be geodesign. Two significant findings emerge as a result of the article's two-part methodology. The first, based on a careful analysis and comparison of design processes, reveals distinction in Steinitz's "Framework for Geodesign" (2012) that sets it apart from related design processes. The second, which is rooted in the discoveries from the first part, resulted in the creation of a recommended Case Study Method for geodesign.

The framework as presented in Steinitz's book (2012), along with other writings and analysis about it, is organized, categorized and discussed in a manner that facilitates comparison with other design theories. The research reveals many similarities to the five other design processes studied. There was however a key distinction that makes this geodesign design process unique. Due to his methodology, which relies on an interrelated set of models, a design team approaches the actual execution of a project in a manner much different than typical design processes. Steinitz's geodesign process is a decision maker-driven structure that is carefully mapped out to facilitate its effective execution. Along with this unique structuring of the process prior to its implementation, analysis of the geodesign process reveals two other essential components: collaborators and digital technologies. These then form the critical core components that establish a process as representative of geodesign.

The second part of the method for this article utilizes the core components as criteria for performing analysis of geodesign projects to establish a case study method that can be used to ascertain the degree to which projects embrace the characteristics of the geodesign process. These core components highlight desirable principles, methods and participants and serve as a foundational vocabulary for dialogue about geodesign. A distinct benefit is that the proposed Case Study Method establishes a structured system for organizing, critiquing and sharing geodesign projects and processes. A deeper aim is that the Case Study Method can inform the future advancement of geodesign.

Wilson (1998) advocates a critical need for integration of knowledge across disciplines to address the challenges facing the world. This article outlines several ways in which geodesign can serve as the vitally important bridge between professions, sciences and the public/stakeholders. The points outlined here provide evidence that geodesign falls within the lexicon of recognized design processes. The core components in the Case Study Method provide a solid foundation for documenting the process and its products, and can serve as a platform from which geodesign can continue to evolve.

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