Can Chaos Theory Solve the Puzzles of Planning?

There are questions that traditional science has not successfully answered. Chaos theory is a response to this lack of success. Based on ideas, calculations, and experiments that go back as far as the 1800s, chaos theory has helped scientists find better ways of understanding and solving problems that defy conventional methods of analysis.

Chaos theorists recognize that traditional science has made and will continue to make substantial contributions to our knowledge and progress. However, they believe that traditional science can not adequately analyze problems as diverse as the evolution of the universe, weather forecasting, the rise and fall of wildlife populations, changes in financial markets, and how people learn.

Bits and pieces of chaos theory have made their way from the scientific community into the general population. Computer-generated "pictures" of chaos have become pieces of art. In the movie *Jurassic Park*, Malcolm the chaotician was a leading character.

Most people, though, have a limited understanding of chaos theory. Planners, in particular, have given the topic little attention.

To learn more about chaos theory, take the ***Chaos Quiz***. There are no right or wrong answers. When you finish, though, you will have a better idea of what chaos theory is and if you think chaos theory has some value.

The Chaos Quiz

Question 1: What is chaos?

a.	**Chaos is disorder.**	**Yes**	**No**
b.	**Chaos is random activity or results.**	**Yes**	**No**
c.	**Chaos is the inability to describe past conditions.**	**Yes**	**No**
d.	**Chaos is the inability to predict the future.**	**Yes**	**No**

In a way, each answer is correct. Chaos is a situation that, to the observer, is disorderly and random. The disorder and randomness, though, may not be real. The chaos may be organized in a way that our tools, knowledge, and perspective do not allow us to see.

Chaos is also the inability to determine what has happened in the past or what will happen in the future. Chaos theorists emphasize the importance of being able to accurately define ***initial conditions***. Chaotic systems are very sensitive to initial conditions. Small differences in initial conditions can lead to vastly different outcomes.

In analyzing a chaotic system for which initial conditions can not be measured accurately, it is impossible to figure out the true causes of the way things are. As well, the ability to predict the future is seriously limited, if not eliminated.

When we encounter a chaotic system, we can see its random nature. It is difficult, though, to tell if the system's behavior is really random or just order cloaked in disorder. As economist Paul Serletis points out, scientists can not find the answer with statistical analysis – their window on randomness. Statistical analysis only shows whether there is a random pattern, not whether there is an unseen order to what is being observed.

Question 2. In your view, are these statements true or false?

a.	**Science can provide definite answers.**	True	False
b.	**Solutions are often not common sense.**	True	False
c.	**It is not productive to answer irrelevant questions.**	True	False
d.	**Intuition can be just as valuable as data in making decisions.**	True	False

If you feel that "b" and "d" are true and "a" and "c" are false, then you recognize some fundamental principles of chaos theory.

It has long been acknowledged that science is not absolutely precise. Decisions are always needed concerning the amount of precision required. Much greater precision is usually needed to uncover the order within a chaotic system.

Chaotic systems often defy common sense. A non-random chaotic system behaves in a way that is called ***non-linear***. This does not mean it is impossible to graph its behavior as a line. Instead, it means the line will be messy and the system's behavior will often be unpredictable. Chaotic systems do not show a smooth relationship between cause and effect. The line showing a chaotic system's behavior may have dramatic jumps or may split, venturing down multiple, mutually incompatible pathways. Sometimes, the line will turn upon itself and head back to where it was.

Like all good science, chaos theory relies on questions that, initially, do not appear relevant and on intuition that unearths answers hidden by hard data. The history of chaos theory shows that a substantial amount of mental agility and intellectual tolerance is required to unveil the order within the apparent disorder of chaotic systems.

When chaotic systems are truly random, it takes a great deal of flexibility to be able to step outside the box of normal scientific thinking and build random elements into the analysis. According to physicist David Hobill, researchers in physics have, out of necessity, been building random elements into predictive models for years. Hobill notes that some physicists have become successful at modelling financial markets because of their ability to incorporate random occurrences.

Question 3. Indicate whether you agree or disagree with the following:

a. It is essential to understand the interaction among components of a system.

Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree	Don't Know
☐	☐	☐	☐	☐	☐

A chaos theorist would strongly agree. In a chaotic system, there are interactions among key components that must be understood.

Simple cause and effect relationships are usually absent in chaotic systems. Instead, feedback loops drive the system. One part of the system affects another but is then changed by the response. These feedback loops can set off a chain reaction where a small change is magnified into a major change to the system as a whole.

b. Human systems create order from chaos if there is a well-defined and accepted purpose to what people do.

Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree	Don't Know
☐	☐	☐	☐	☐	☐

Chaos theorists are not in agreement as to whether it is possible to fashion chaos into orderly human behavior simply through an understanding and acceptance of the objectives and rules. Some believe there is evidence that people will respond appropriately. Others feel that, even if order could arise from people's initial buy-in, the sensitivity to initial conditions will cause people's behavior to return to a chaotic condition.

c. Cooperation is more important than individual freedom.

Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree	Don't Know
☐	☐	☐	☐	☐	☐

Chaos theory has not found the happy medium between people's desire to do what they want and their interdependence with others. There is some evidence, primarily from biology, that mutually beneficial behavior, rather than competition, is a more successful survival strategy.

d. Systems that operate close to a state of chaos are better able to adapt.

Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree	Don't Know
☐	☐	☐	☐	☐	☐

Most chaos theorists would disagree that operating on the edge of chaos improves the ability to adapt to change. There was some research with computerized "life forms" (called ***cellular automata***) that appeared to show better adaptability in near-chaotic conditions. Those results have since been disproved.

e. Chaos leads to new forms of order that are better than what previously existed.

Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree	Don't Know
☐	☐	☐	☐	☐	☐

This is a value judgement unsupported by chaos theory. The philosophy of "If it ain't broke, break it." is not valid.

f. People's behavior is often irrational.

Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree	Don't Know
☐	☐	☐	☐	☐	☐

A chaos theorist would neither agree nor disagree that behavior is rational or irrational. From the standpoint of chaos theory, irrationality is irrelevant. The important thing is to understand why people behave in a certain way rather than make value judgements about that behavior.

What Does This Mean for Planning?

That provides a glimpse into chaos theory. But does chaos theory have something to offer the planning profession? Is there wisdom that can be translated from chaos theory to planning? Are there techniques for analyzing chaos that could make planning more efficient and effective?

Planning problems are often chaotic. They are not tidy and are vulnerable to unexpected circumstances. Similar solutions may produce different results or the results will not be predictable within an acceptable level of comfort.

Recognition that there is a fundamental difference between chaotic and non-chaotic problems is the first benefit that chaos theory can provide to planning. A planner must know what the problem is, not in the ordinary way of knowing the facts, the players, and the stakes. Instead, based on chaos theory, a planner must determine if a problem has a "life of its own," that is, it exhibits the unpredictable behavior of a chaotic system.

If the problem is chaotic, chaos theory provides some guidelines that might be helpful in planning:

- **Be sensitive to initial conditions:** A chaos theorist would advise a planner to know how a problem got to be the way it is. If it is not possible to determine the factors that led to the need for a plan, it is unlikely the problem can be solved. This requires a genuine examination of what went wrong and what went right, not just falling back on excuses like there was a drought or no one realized the farmers' licences would be cut-off and the fish would die. This will mean considering and, in some cases, challenging sacred cows like objectives, decision-making procedures, and the assumptions people take for granted.

A chaos theorist would also advise that it is critical to accurately define where you are now. This applies to data on physical factors such as natural water supply and water quality. More importantly, there must be accurate information about people's knowledge, objectives, and values, how they will react to trade-offs during the planning process, and how potential changes could influence their behavior.

- **Learn to cope with uncertainty:** As chaos theory has confirmed, life is a matter of probabilities with no guarantee that common sense, conventional questions, and statistics will make it easier to figure out the future. The world's dam failures demonstrate that even hard-core engineering is susceptible to probabilities, whether they are physical risks like earthquakes and seepage or human risks like ignorance and graft.

  A planner needs to choose how to deal with uncertainty. There is no magic answer, except that uncertainty can not be ignored. It may be a question of cutting down the uncertainty by working harder and smarter – and probably spending more money. It may be a question of building in monitoring and fail-safe mechanisms to ensure that a plan can self-correct if it wanders too far from the chosen path. It may simply be a question of pointing out the uncertainties and acknowledging that a plan is – to one extent or another – an experiment.

- **Understand the interactions:** In handling chaotic problems, a planner does not have the luxury of dealing with straightforward cause-effect relationships. In water management, for example, weather is a dominant factor. Yet, weather is extremely sensitive to small changes that, through feedback loops, determine, for example, if it rains or not. Data on tree rings and the changing climate indicate that, because of these interactions, we are likely to see more unpredictability in our future weather.

  In a chaotic system, action items from a plan will cause reactions that will, in turn, cause other reactions and so on. These feedback loops are likely to magnify or diminish the intended impact of the plan.

  A plan presents opportunities that some people will exploit. The classic example is a reservoir that fails to alleviate water shortages because too many users get a slice of its limited storage. With each additional allocation from storage, water users expand their activities, assume greater risk, and exert more pressure to cash in on the reservoir's bounty. Finally, the reservoir can no longer handle the demand and shortages once again become a fact of life.

  A plan also creates changes that some people will resist. Water conservation measures often run into trouble because of this resistance. Some water users do not do what they should to conserve, thus encouraging others to follow suit and eventually causing a regulatory authority to step in with more draconian measures that, in some cases, cause an increase in water consumption.

  Understanding interactions also means looking for those feedback loops that are beneficial, but have either withered from disuse or disappeared entirely. These diminished feedback loops are symptoms of ***limit cycles***, which keep the behavior of a system within the boundaries of what is considered a safe and acceptable routine.

- **Eliminate the randomness, accentuate the probable:** Researchers into chaos are continuing to search for order in chaotic systems. Planners dealing with chaotic problems need to do the same. They need to continue refining their data on things like natural flow and water quality even if that means adopting messier, but more realistic non-linear techniques – including qualitative analysis.

  To be able to counteract randomness, planners may also need to embrace randomness. The problem with randomness is its uncertainty. Planners might follow the lead of physicists and blend random elements into their data. This, of course, does not eliminate the uncertainty in the data but, like sensitivity analysis, can reduce the effect of uncertainty on the plan that is eventually adopted.[1]

People are the greatest potential source of randomness in a planning process. In particular, that thing we call politics is the element in human nature that traditionally creates the most perplexing possibility of arbitrary intervention.

Based on chaos theory, the solution to the dilemma of politics and planning is not, as some have suggested, for a planner to become political. Instead, chaos theory offers a two-part solution. First, define the political needs and processes, that is, identify the underlying order within the political system. Then, eliminate the limit cycles (i.e., constraints) that would spawn political chaos. This could include traditional tactics such as reducing the gaps in decision-makers' knowledge and making sure the process remains fair and open. It might also involve a greater overlap and possibly full unification of the planning process with the decision-making process.

Politics will always be a part of planning. The challenge is to turn what might become random acts of politics into probable causes for success.

If you want to find out more about chaos theory, these sources should be helpful:

- http://pespmc1.vub.ac.be/CHAOS.html
- http://order.ph.utexas.edu/chaos/

  These websites provide clear explanations of the basics of chaos theory.

- James Gleick, *Chaos: Making A New Science*, Viking, 1987.

  A very readable book on the history of chaos theory.

- John Briggs and F. David Peat, *Turbulent Mirror*, Harper & Row, 1989
- John Briggs and F. David Peat, *Seven Life Lessons of Chaos: Timeless Wisdom from the Science of Change*, HarperCollins, 1999.

  Two books that review the history of chaos theory and speculate on its future application.

- Richard O. Mason and Ian I. Mitroff, *Challenging Strategic Planning Assumptions: Theory, Cases and Techniques*, John Wiley & Son (Wiley-Interscience), 1981

  A book on planning for situations of "organized complexity," an idea very similar to the concept of chaos.

- *Bob Morrison*

Thanks to Dr. David Hobill, Dr. Paul Serletis, and Dr. Lorne Taylor for their advice on chaos theory.

[1] This does not mean that all randomness is bad or important to consider. For example, the randomness of irrigation or lawn watering by individuals can be a good thing. If each individual acted in the same way, peak demands would increase and overload the system.