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Exploration of the Complex Ontology

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Abstract. The Oxford English Dictionary (OED), the established definition of words in the English language, is at odds with other definitions of complexity proffered by Complexity Theory. This variance is likely to cause confusion in the delivery community. The incorrect classification of a project between 'complicated' and 'complex' is considered by some to be a major source of project failure; resolving this issue is therefore critical. This paper explores the definition of complexity by assessing definitions from various sources and by conducting a survey of over 100 delivery professionals. The results demonstrate the extent of the confusion and have informed considerations on how to resolve this. This paper recommends that it is essential that the definition is either defined at the start, or that the term is avoided by using its components. This paper identifies a simple modification to the OED definition that would resolve many of the issues, if implemented.

Introduction

Globalization and its associated information explosion mean that many delivery tasks are defined as being complex. Consequently, delivery professions have risen to the challenge. The system engineering profession prides itself on its ability to handle complex delivery tasks. In project management, agile methodology has been developed, to a considerable extent, to accommodate modern complex delivery requirements [1]. 'Complex' and 'complexity' have also become buzzwords that justify significant further investments, an individual's recognition, and the selection of alternative approaches to delivery.

Despite this global-scale response to the rise of complexity, the term 'complex' itself is poorly defined. This causes significant confusion. The term is often referred to as being difficult to define [2]. Some have stated that one will know that something is complex when one sees it [3]. Meanwhile, others stick to the dictionary definition, treating it at best as a synonym of 'complicated', which, for many in the delivery community, is almost the antithesis of 'complex'. A potential reason for this confusion is that aspects of the Complexity Theory definition are increasingly becoming established in the minds of the delivery community, but not to the full extent and detail that these theories define. Consequently, it is possible that different aspects of these theories and definitions are established in different minds, including potential over-simplifications.

The challenge of being able to define complexity with clarity is reflected in the complexity tools that have emerged. Many use titles to define categories of complexity that are unique to the tool; e.g. cow, bull, horse [4], or wicked, messes, and wicked messes [5, 6]. Use of such terms appears to be the byproduct of an immature lexicon to describe the types of difficulty or complexity being observed, or a justifiable attempt to avoid contentious definitions. Some tools have 'complexity' in their heading,

axis and as an output, with different definitions for complexity being implied at each level without explanation, confusing the reader and breaking category boundaries. Many simple project categorization tools include ‘simple’, ‘complicated’, ‘complex’ and ‘chaotic’ [7, 8, 9, 10] as the categories. Although these tools demonstrate support for there being a different meaning for a complicated and a complex system, supporting Complexity Theory, they run contrary to dictionary definitions for complex, complicated and chaotic, potentially having a profound impact on maintaining the consistency of commonly accepted terms.

The absence of an agreed ontology has not gone unnoticed, and has led some to determine that there is no rigorous definition [11] or that the term is user-specific. This lack of clarity suggests either that a clear definition is impossible or that the current definition may not be complete.

If the definition of these terms was inconsequential then the confusion might be more acceptable. However, it has been noted by Michael Cavanagh of The International Centre for Complex Project Management that the misclassification of a project as a ‘complicated’ task rather than a ‘complex’ one was a major cause of project failure [12]. A plethora of stories support the importance of understanding the difficulty and adjusting to it. For example, it was a change of approach to accommodate complexity that enabled both NASA to get the first man to the moon, despite trialing for many years prior, and for the US Army to defeat AQI in Iraq [13]. Consequently, it would appear that not only is the definition uncertain, but also that this uncertainty could be a major cause of failure for many substantial projects across the globe.

The purpose of this paper is to examine the ontology of complexity by looking at the definitions as used by a range of sources in the hope that a clearer definition or understanding can be developed. This paper will focus on the objective assessment of delivery complexity with the aim of supporting the delivery practitioner in identifying complex tasks effectively. The expectation is to move the definition of delivery complexity discussion along, rather than to finalize it.

Relationship to existing theory and work

It is worth stating at the outset that the authors’ understanding of complexity is historically from a delivery perspective. As part of the literature survey, we draw on insights from Chaos Theory and Complexity Theory and the insights that can be gleaned from Difficulty or Complexity assessment tools. The authors specifically avoid discussing the vast range of definitions on complexity that emerge from Complexity Theory in the many professional bodies and delivery approaches, instead aiming to use the salient points that have come to the fore that can provide insights into what definitions are most recognized by delivery professionals and therefore can be used to help determine whether a task is complex or not.

Approach

The approach taken in this paper is to consider definitions of complexity and associated words as derived from the following sources:

1) Dictionary definitions (Oxford English Dictionary [14]; Collins Dictionary [15]).
2) Definitions as implied by developed complexity, difficulty or risk assessment tools that explicitly deal with uncertainty. There are many project management complexity assessment tools that use ‘complexity’ as a synonym of ‘complicated’; these have been ignored for the purposes of defining complexity, as they provide no value.
3) Generic definitions as implied by common mathematical theories.

The definitions will be compared, contrasted and analyzed so that a suitable range of options can be identified for clarifying the definition of complexity and/or its associated terms. The associated words to be examined in addition to complex are: difficult, complicated, chaos, chaotic, emergent and uncertainty.

From this analysis, a survey is constructed that tests the prevailing view of over 100 delivery professionals from both the public and private sectors. The results are presented and conclusions and recommendations are drawn from the analyses and results.

Literature review

In describing the outputs of the literature review it is not possible to describe one element without using definitions from other elements. Consequently, it is not possible to order these definitions such that the reader can move from one definition to the next with a full understanding. Instead, all definitions need to be read and understood to fully understand each one. Some terms are well defined, but a discussion of all of them is required to put the definition of complexity into the right context.

The tables below are RAG coded. The table cell color indicates the alignment of the definition within that source; the alignment column indicates the alignment between the different sources of definition. For example, a definition can be aligned within all three sources of definition, but those different sources can be at odds with each other. Red indicates disagreement between the definitions; amber indicates inferred differences; green means largely aligned.

Difficulty:

Figure 1. Table detailing the definitions of 'difficulty' from dictionary, tools and mathematical theories. The RAG color indicates the amount of alignment in definition.

Source	Definition	Alignment
Dictionary:	OED: Needing much effort or skill to accomplish, deal with, or understand. COLLINS US: Hard to do, make, manage, understand, etc.; involving trouble or requiring extra effort, skill, or thought. COLLINS UK: Not easy to do; requiring effort; a difficult job; not easy to understand or solve; intricate; a difficult problem; hard to deal with; troublesome.	
Tools	Aligned to above.	
Theories	Not discussed.	

This term is explored because of its ability to replace the use of the 'complex' term in the title of many tools. Often tools are called 'complex', suggesting that they measure the amount of complexity in a task. However, their output is typically 'simple', 'complicated', 'complex' or 'chaotic'. This suggests that they indicate that the amount of complexity as you move from 'simple' to 'complicated', to 'complex', and then to 'chaotic' is increasing. This can lead to confusion. One way to resolve this is to use 'difficulty' as a measure/title instead. Difficulty is the amount of skill and/or effort required to complete an activity. Classifying tasks as 'simple', 'complicated', 'complex' or 'chaotic' infers the types and amount of skill or effort required to deliver the task.

Uncertainty:

Figure 2. Table detailing the definitions of 'uncertainty' from dictionary, tools and mathematical theories. The RAG color indicates the amount of alignment in definition.

Source	Definition	Alignment
Dictionary:	OED: Not able to be relied on; not known or definite. COLLINS US: Lack of certainty; doubt; the state or condition of being uncertain; an uncertain matter, contingency, etc. Definition of Certain: Fixed, settled, or determined; sure (to happen, etc.); inevitable; not to be doubted; unquestionable; not failing; reliable; dependable; unerring; without any doubt; assured; sure; positive. COLLINS UK: Positive and confident about the truth of something; convinced; definitely known; sure; bound; destined; decided or settled upon; fixed; unfailing; reliable.	
Tools	Sometimes synonymous with unfamiliarity (not know), sometimes synonymous with unpredictability (not able to rely upon). Rarely are both aspects of uncertainty treated. Often applied to the inputs of system development (requirements and solution). The uncertainty of the system that delivers tends to be treated in isolation.	
Theories	Output uncertainty is closely aligned with emergent behaviour. 'Emergent', however, is the space of unknown unknowns, whereas uncertainty covers known unknowns as well.	

Uncertainty is inherently related to complexity and chaos. Consequently, this term is popular as an axis in delivery complexity tools. Typically, it is the unfamiliarity in the requirements (don't know what) and/or with the solution (don't know how) [7, 8, 9] that is measured, as shown in Figure 3 below.

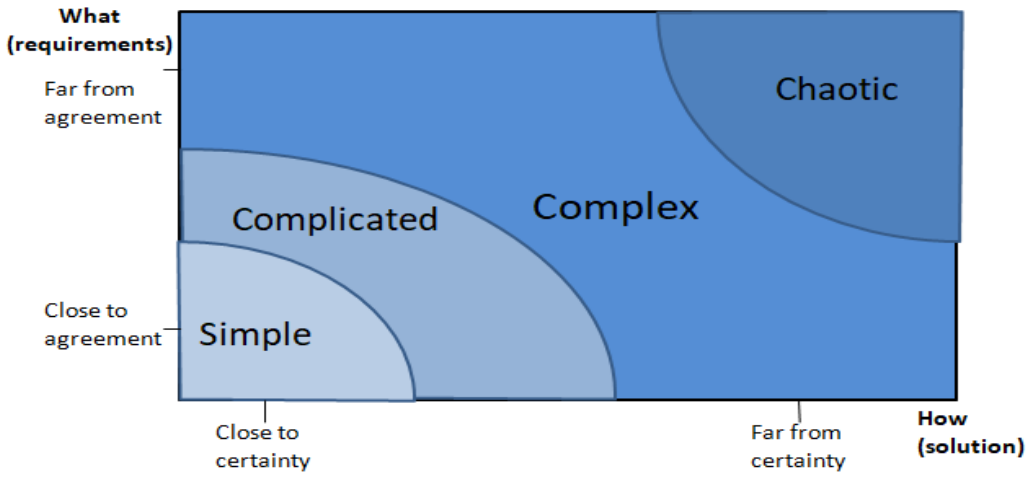


Figure 3. A representation of a simplified Stacy matrix [9] indicating the association of complexity with uncertainty in the What (requirements) and the How (in this instance, technology), which is synonymous with solution.

These tools are used as an indicator of uncertainty in the outcomes categorized as simple, complicated, complex or chaotic, inferring that 'complicated' has a measure of uncertainty within it, and that 'complex' is more uncertain, and hence more difficult, than 'complicated'.

The challenge with the tools approach is that defining 'complicated' as containing 'some uncertainty' does not objectively fit the description in the OED or in Complexity Theory. However, it does fit subjectively with how tasks and projects are delivered, in that complicated approaches can be used to handle some uncertainty, and complex approaches are used to handle more uncertainty. The challenge with this simplified view is that 'uncertainty' can readily be separated into uncertainty with the current state (or familiarity) and uncertainty with the future state (unpredictability). The uncertainty measured above appears to be associated with the familiarity of the task at the start; it does not take into account the uncertainty during execution between the component parts (unpredictability) of the system that makes the system (also known as the machine that makes the machine, or M3) [16]. Typically, the M3 system is unpredictable due to human decision-making. Both lead to unpredictability as to what the final product of the system to be made is (also known as the machine to be made, M2M) [16] and how much uncertainty is inherent in that system.

This suggests that multiple types of delivery uncertainty exist that also need to be considered. These can be considered collectively or in isolation, as described in Figure 4 below.

Figure 4. A table to indicate how input familiarity and system unpredictability combine to create increasing levels of uncertainty in a system output.

	Known and predictable delivery system	Unknown or unpredictable delivery system
Familiar with how and what	1. Deterministic, predictable outcomes	2. Uncertain outcome
Familiar with how or what	3. Uncertain outcome	4. Highly uncertain outcome
Unfamiliar with how and what	5. Highly uncertain outcome	6. Extremely uncertain outcome

Emergent (Emergence):

Complexity Theory, on the other hand, tends to discuss 'emergence' instead of the unpredictable aspect of 'uncertainty'. This term is popular in systems engineering. However, in the delivery community, some confusion could arise between 'uncertainty' and 'emergence', from the philosophical definition of 'emergence' as used in Complexity Theory, and the more commonly understood meaning, which is aligned to the Middle English or US definition (see Figure 5 below).

Figure 5. Table detailing the definitions of 'emergent' from dictionary, tools and mathematical theories and other sources. The RAG color indicates the amount of alignment in definition.

Source	Definition	Alignment
Dictionary:	OED: 1. In the process of coming into being or becoming prominent. 2. Philosophy (of a property) arising as an effect of complex causes and not analysable simply as the sum of their effects. 3. Middle English: Occurring unexpectedly. COLLINS US: Arising unexpectedly or as a new or improved development; recently founded or newly independent.	

	COLLINS UK: Coming into being or notice; (of a nation) recently independent.	
Tools	If discussed, more in terms of OED 3 or COLLINS US above (arising unexpectedly).	
Theories	Emergence often discussed in Complexity and Chaos Theories as defined in OED definition 2 above.	
Other	The whole is more than the sum of the parts, non-linear. [11]	

Emergence in Complexity Theory differs from uncertainty in that it is focused around the unknown unknown aspects of the outputs (predictability), whereas uncertainty covers the known unknowns and the unknown unknowns of both familiarity and predictability. As such, it is either a subset of or a synonym for 'unpredictability', depending on which OED definition is used.

Subjectively, however, an inability or unwillingness of the observer to analyze what the sum of the effects of a system is means that it will often not be possible to separate the terms. As Complexity Theory thinking, and hence the term 'emergence', permeates the thoughts of the delivery community without proper introduction, there is a risk of confusion between the US/Middle English term (unpredictability) and the philosophical term favored by Complexity Theory (unknown unknowns). In addition, both the M3 and M2M system can exhibit philosophical emergence in addition to the unpredictability that can be caused by the known unknowns.

Complicated:

The definition of complicated is universally agreed upon across dictionaries and in mathematical theories as consisting of 'many interconnecting parts or elements; intricate'. All definitions notably exclude any reference to uncertainty.

Figure 6. Table detailing the definitions of 'complicated' from dictionary, tools and mathematical theories and other sources. The RAG color indicates the amount of alignment in definition.

Source	Definition	Alignment
Dictionary:	OED: Consisting of many interconnecting parts or elements; intricate. Antonym = Easy, simple, straightforward. COLLINS US: Made up of parts intricately involved; hard to untangle, solve, understand, analyze, etc. COLLINS UK: Made up of intricate parts or aspects that are difficult to understand or analyze.	
Tools	Some tools infer [7, 8, 9, 10] that complicated systems have some uncertainty. Others assume no uncertainty [16].	
Theories	Generally discussed as the absence of uncertainty.	

In Complexity Theory, the definition of an intricate system without uncertainty is complicated. So 'complicated' is strictly defined as not having uncertainty. The dictionary makes no reference to uncertainty. This is important because the dictionary description of 'complex' infers or states that it is a synonym of 'complicated'. As discussed above, some tools, such as those shown in Figure 1, indicate that there is some uncertainty in complicatedness. It is assumed that these tools are using the subjective delivery definition, which accommodates the fact that complicated delivery tools are able

to cope with some uncertainty, as demonstrated by the importance of risk logs. Indeed, it can be argued that the greater the skill of the practitioner, the more uncertainty he or she can handle using tools designed for a largely complicated task.

Chaos (Chaotic):

Figure 7. Table detailing the definitions of 'chaos' from dictionary, tools and mathematical theories sources. The RAG color indicates the amount of alignment in definition.

Source	Definition	Alignment
Dictionary:	OED: 1. Complete disorder and confusion. Antonym = Order. 2. The property of a complex system whose behaviour is so unpredictable as to appear random owing to great sensitivity to small changes in conditions. Chaotic systems that exhibit either 1 or 2 above. COLLINS US: 1. Extreme confusion or disorder. 2. Ancient Mathematics: a pattern or state of order existing within apparent disorder, as in the irregularities of a coastline or a snowflake. COLLINS UK: Complete disorder; utter confusion.	
Tools	Significant uncertainty in the requirements and solution of a task that combine to create chaotic outcomes. A combination of high unpredictability, intricacy and unfamiliarity that means that the outputs are unlikely to be aligned to expectations.	
Theories	Chaos Theory: A system that appears random due to the high sensitivity of the input parameters, although in actual fact the system is deterministic and hence repeatable if the exact same inputs are used. Otherwise it appears random. Complexity Theory: Chaos is an extreme form of complexity; i.e. highly emergent.	

Chaos Theory definition requires absolute predictability in the system. As such, it falls outside the Complexity Theory definition of a complex system, which mandates unpredictability or the non-deterministic nature of the system. This Complexity Theory definition does include chaotic systems that are non-deterministic. A chaotic system produces outputs that are so unpredictable, even if repeated exactly, that they seem unrelated with the inputs. This is treated as a subset of a complex system where the unpredictability or emergence is extreme. A Chaos Theory system, however, only emulates this system, while it is in fact a deterministic system and hence is repeatable. Consequently, the Chaos Theory definition does not match the dictionary definition of chaos as a subset of a complex system, or as a system with complete disorder and confusion. However, the OED definition of chaos uses terminology that indicates that it directly references Chaos Theory, albeit notably minus the deterministic clause. Consequently, it appears that the definition of chaos in the OED responds to the Complexity Theory definition of emergence, but actually uses unpredictability instead.

The prevalent use of 'unpredictability' suggests that a soft or adulterated form of Complexity Theory definition is being established where 'unpredictability' replaces 'emergence', and where many of the other aspects of Complexity Theory definition, such as context and history-specific and feedback loops are simplistically folded into the 'unpredictable' banner. One could consider this a 'soft' Complexity Theory definition.

An example of this in the tools, as illustrated in Figure 3 above, is where chaos is defined as significant uncertainty (unfamiliarity) in the requirement and solutions space [a], where a complex

system shows only some uncertainty (unfamiliarity) in these two elements. This indicates that a chaotic system is an extreme form of a complex system with more uncertainty (unfamiliarity), and that the definition of 'chaotic' as an extreme form of 'complex' aligns to all definitions. However, chaotic and complex systems focus on the unpredictability or emergence in the system, not the familiarity discussed in these tools.

Complex:

Figure 8. Table detailing the definitions of 'complex' from dictionary, tools and mathematical theories and other sources. The RAG color indicates the amount of alignment in the definition.

Source	Definition	Alignment
Dictionary:	OED: Consisting of many different and connected parts; not easy to analyse or understand; complicated or intricate. Antonym = Simple or straightforward. COLLINS: Consisting of two or more related parts; not simple; involved or complicated. Synonym note: 'complex' refers to that which is made up of many elaborately interrelated or interconnected parts, so that much study or knowledge is needed to understand or operate it [a complex mechanism]; 'complicated' is applied to that which is highly complex and hence very difficult to analyze, solve, or understand [a complicated problem]; 'intricate' specifically suggests a perplexingly elaborate interweaving of parts that is difficult to follow [an intricate maze]; 'involved', in this connection, is applied to situations, ideas, etc. whose parts are thought of as intertwining in complicated, often disordered, fashion [an involved argument]. The opposite of 'complex' is 'simple'.	
Tools	Some uncertainty in the requirements and solution of a task [7, 8, 9, 10]. Complex is a task with considerable uncertainty, which is however possibly manageable using the right approaches by acceptance and embracing of that uncertainty as in Agile delivery methods. Intricacy and unfamiliarity in the task are sufficiently high that unexpected or emergent outcomes may arise [db]. It is considered much more challenging to handle than complicated systems. Cynefin definition [17] reflects Complexity Theory definition.	
Theories	Difficulty to define, but inconclusively specified as a system that exhibits: 1. Emergence (see above). 2. Is non-deterministic. 3. Has feedback and hence is able to resist or amplify change (is self-healing as in rainforests). 4. Not necessarily complicated (intricate). The opposite of complexity is clarity.	
Other	A complex system exhibits emergence [11]. The whole is different from the sum of the parts, history matters, sensitive to context, emergent, episodic (activity in fits and starts) [boulton]. Project managers characterize it as complicated + uncertainty [2],	

	adaptive systems, self-organization & emergence [2].	

‘Complex’ as defined in dictionaries is essentially a synonym of ‘complicated’, with its opposite being ‘simple’ (Collins). The dictionary definitions are closely aligned. However, the Complexity Theory definition is also mature, although notably not finalized, and agreed across many communities. These two definitions are at odds with each other. This is most obvious when looking at the Synonym note in the Collins dictionary, which explicitly states that ‘complicated’ is a more challenging form of ‘complex’; i.e. ‘complex’ is hard to understand and ‘complicated’ is very hard to understand. This directly contradicts the delivery community’s understanding and tools usage of the term.

Many delivery methods for handling complexity are aligned closely to the Complexity Theory definition in that it has emergence or unpredictability as a key element. However, this alignment often does not go down to the exact description of ‘complex’ as described by Complexity Theory. In particular, tools and methods appear to use a soft form of ‘complex’ as specified by Complexity Theory in that ‘emergent’ is synonymous with ‘unpredictability’ in the round.

Consequently, tools are roughly aligned to Complexity Theory, but Complexity Theory is in complete disagreement with both dictionaries, particularly Collins. As the difference between these definitions leads to different delivery methods, this is critical to resolve or clearly understand at least from a delivery community perspective. It has already been mentioned that the misclassification of a project as ‘complicated’ instead of ‘complex’ is considered by some the main source of project failure [2]. The confusion caused by the use of an alternative definition throughout much of the delivery community to that used in dictionaries can only exacerbate the issue.

Analysis

As can be seen, based on current definitions, it is not possible to resolve the definitions of complexity, chaos and complicated systems without breaking one of the associated OED definitions, and/or stepping out of line with the developed theories. Either these issues need to be resolved or the full ambiguity of these terms needs to become more commonly understood and communicated for clear discussions around complexity to take place.

By analyzing all the terms reviewed above it is hoped that one or more suitable solutions to resolving the definition of complexity can be identified, around which the community might coalesce.

Summary of the issues

Before we start the analysis it would be valuable to summarize the issues.

1) Dictionary definitions are not aligned: ‘Chaos’ is defined as ‘a complex system whose behaviour is so unpredictable as to appear random owing to great sensitivity to small changes in conditions’. This suggests that a complex system typically exhibits unpredictable behaviour, and that a chaotic system is an extreme case of this. The definition of ‘complex’ is synonymous with ‘complicated’, with no reference to unpredictability. Collins Dictionary goes a step further and suggests that a ‘complex’ problem is easier to deliver than a ‘complicated’ problem. These definitions seem to contradict one another.

This issue can also be considered by looking at the opposites. The definition of chaos indicates that a complex system has unpredictability; hence the opposite would be ‘predictability’. The definition of complex indicates that the system is intricate; the opposite is ‘simple’ or ‘straightforward’, as is the case for ‘complicated’.

In addition, the definition of emergence, a form of uncertainty, indicates that it arises from a complex system. It appears that Complexity Theory definitions have been identified in some terms within the dictionary, but not in the complex or complexity terms.

2) Dictionary and Complexity Theory definitions of complex are not aligned: Complexity as defined in the dictionary does not align to the Complexity Theory definition. The increasing pre-eminence of Complexity Theory means that this clash should not be ignored. It is possible that the emergence of Complexity Theory ideas among delivery community members who have not otherwise studied it is causing the confusion. However, it appears that the soft form of 'complex' as defined in Complexity Theory is emerging, in part because it is not possible to define 'complex' as in Complexity Theory properly in less than a page or two, and that the definition is itself contended.

3) Chaos Theory is not a complex system: Complexity Theory states that a complex system is emergent: the sum total of its parts cannot be used to predict its outcome; i.e., it is not deterministic. A Chaos Theory system is specifically a deterministic system where the sum total of all its parts can be used to predict its behaviour, but due to the hyper-sensitivity of the inputs it looks like a complex system. It is explicitly a counterfeit complex system. This means that in the description of 'chaos' the OED references a complex system, but largely uses the definition of a Chaos Theory system, minus the term 'deterministic'. The absence of this term means that one must assume a complex system even though the terminology infers a Chaos Theory system. This first description of complete or extreme disorder or confusion aligns well with Complexity Theory definitions as chaos as an extreme form of complexity that has emergent (or unexpected outcomes).

Survey structure

To further analyze the definition of complexity as observed by the delivery community, a survey was constructed based on the above discussion. The focus of the survey was to:

1) identify what definitions were most recognized by the professional delivery community and consequently determine how best to communicate and discuss complexity and its associated terms.
2) determine to what extent the Complexity Theory definition had permeated this community in hard or soft form.

To achieve this, the dictionary definitions, along with definitions that reflected both the hard and soft forms from Complexity Theory, and the tool definition inferred by Figure 1, were presented to over 400 delivery professionals in the public and private sectors, with over 100 responses split between system engineers and project managers. The questions asked were:

Question 1) Please indicate in order of preference [1, 2, 3, etc] these definitions of system complexity that you agree with. If you disagree, please indicate with a 'd'.

a. Consisting of many different and connected parts, not easy to analyze or understand, complicated, intricate.
b. Consisting of parts where the whole is different (greater or less) from what could be determined by the sum of the parts, exhibiting feedback mechanisms, where the outcome is also dependent on the context and history.
c. Consisting of many different and connected parts, not possible to fully analyze or understand, leading to uncertainty in the outcome.
d. Consisting of any elaborately interrelated or interconnected parts, so that much study or knowledge is needed to understand or operate it [a complex mechanism]; whereas complicated is applied to that which is highly complex and hence very difficult to analyze, solve, or understand [a complicated problem].
e. A system/task where some uncertainty in the requirements and the solution makes it difficult to deliver, where more uncertainty in the requirements and the solution would make it chaotic to deliver and less uncertainty would make it complicated.

f. Other: Please specify_____

Answer (a) is the OED definition of complexity. Answer (b) reflects the Complexity Theory definition in a few words using key principles. As noted above, these definitions typically take many paragraphs, so any attempt to condense them will be considered a poor imitation. The use of a fuller definition was considered prohibitive to being able to conduct the survey; consequently, the aim was to be close enough. The answer purposely does not use the term 'emergent'; instead, the definition of emergent was used. The reason for this, as discussed above, is that the definition of emergent is ambiguous too; therefore we used the Complexity Theory definition of emergent to reduce confusion. Answer (c) is an extended OED version and was designed to test the acceptance of a soft version of complexity, as discussed above, with minimal change. Again how best to do this is not readily obvious and is subject to interpretation; however, it only needed to be close enough to indicate the intention. Answer (d) is a clarifying note in the Collins Dictionary. Answer (e) was designed to reflect the diagrams used in delivery methodologies to determine whether a task is complex or not, as shown in Figure 3. It is useful to see whether the Figure diagram, which is often presented and readily accepted, was equally accepted when written down in text, forcing a more objective response. Answer (f) was used to check that no obvious definition had been missed.

A second question was also asked.

Question 2: Please indicate the level of difficulty associated with the following words [1 = not difficult; 4 = most difficult]: complex, chaotic, simple, complicated.

This question was asked to check the validity of the assumption that 'complex' is considered more difficult than or equally difficult to 'complicated', a principle supported by all the definitions, as illustrated in Figure 3, apart from the Collins note, which suggests that 'complex' is less difficult. This question can also be used to check whether respondents had read the Collins definition correctly, as it is possible for the answer to question 2 and Collins Dictionary to contradict each other. In addition, the survey was introduced as a one-minute activity; however, the Collins note is considered by the authors to be too complicated for a quick survey. Observation of the contradiction can be used to indicate whether the respondents were using their intuition (or system 1) or their logical thinking (system 2) [18] to respond to the survey.

Results

The results to question 1 of the survey are shown below in Figure 9. To assess the level of alignment to each definition, the top two preferred definitions of each respondent were summed and compared to the number of respondents who disagreed with the same definition.

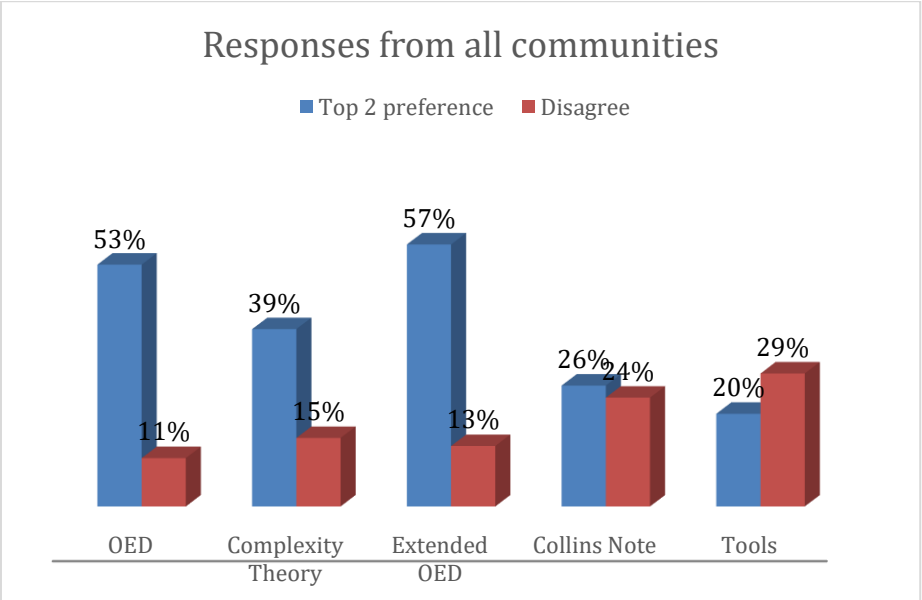
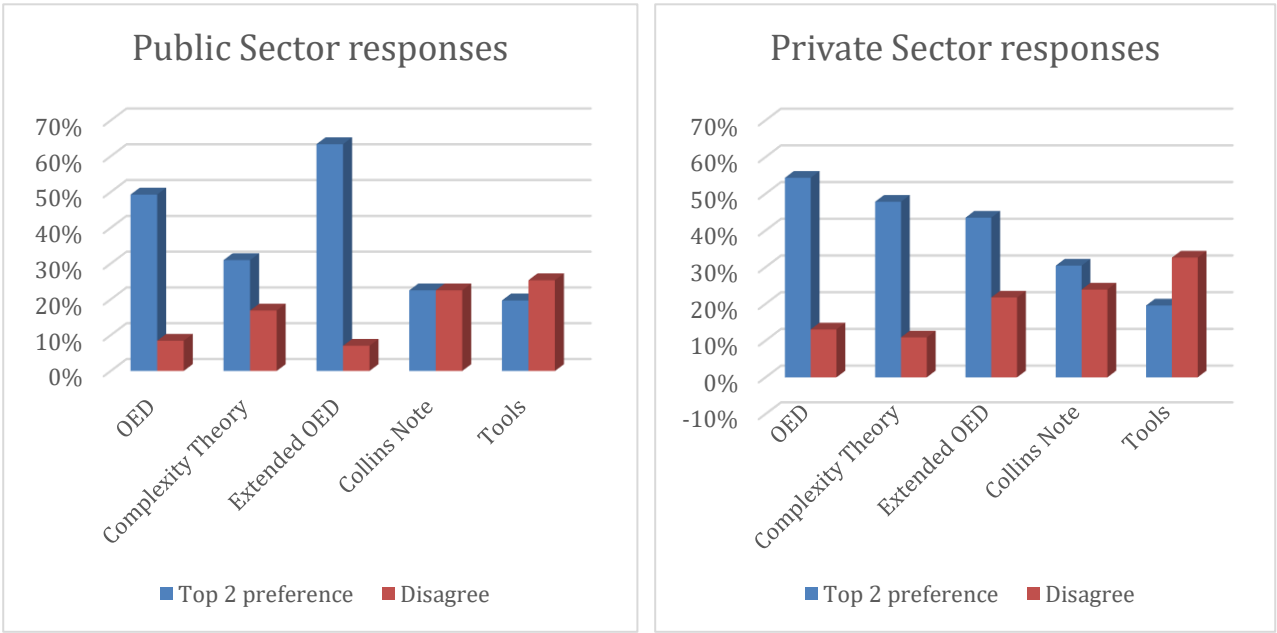


Figure 9. A graph to indicate the number of respondents who selected each definition within the top two preferred definitions of complexity and the number of respondents who indicated that they disagreed with the same definition.

It can be seen from Figure 9 that the tools that are accepted subjectively are largely rejected when assessed objectively. This does not mean they are not useful subjectively, however. The Collins note is also highly controversial. The most relatable definitions, the OED and the extended OED, however, still had more than 10% of the respondents directly disagreeing. This indicates confusion and a lack of alignment of the definitions across the delivery community.

The results can also be analyzed via both community and sector, as shown in Figure 10 below.



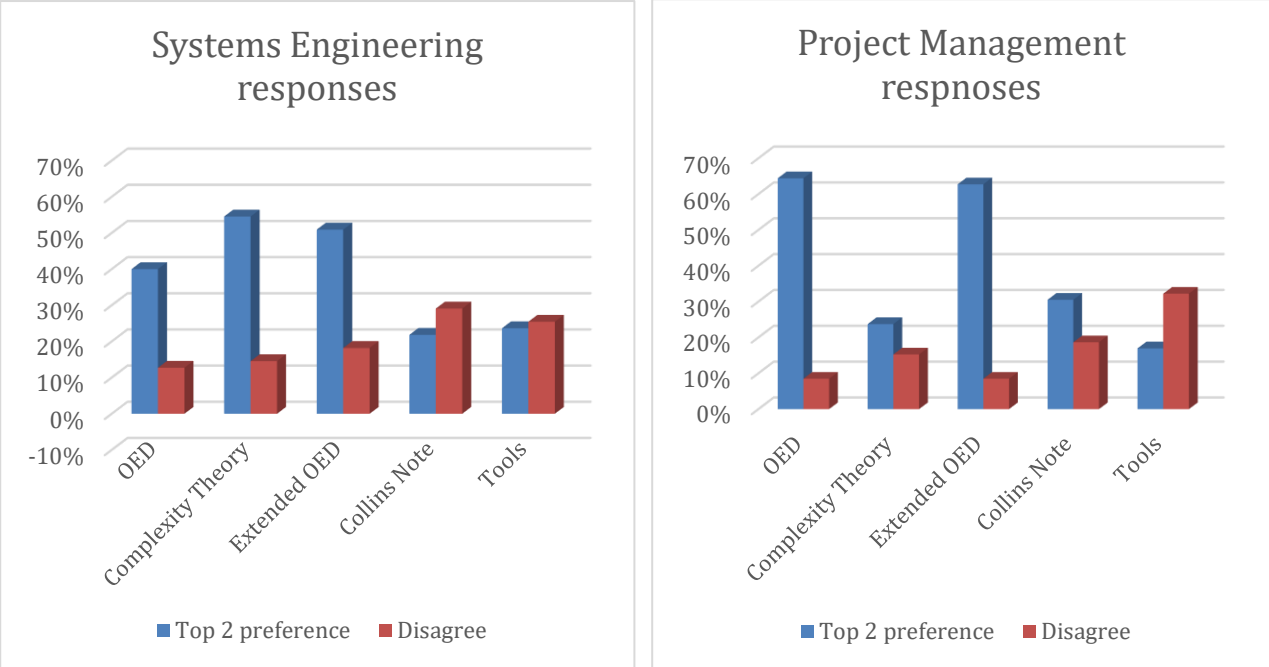


Figure 10. Graphs to indicate the number of respondents who selected each definition within the top two preferred definitions of complexity and the number who indicated that they disagreed with the definition, from the public sector, private sector, project management and systems engineering communities.

Both private- and public-sector communities showed similar support for the OED definition. The difference appears to be the acceptance of the Complexity Theory definition. The private sector preferred the full Complexity Theory definition, while the public sector strongly preferred the extended OED version. Comparing the systems engineering and project management communities, the acceptance of the Complexity Theory definition is again the prevailing difference: the systems engineering community supported it in first place, while the PM community ranked it in fourth place. These results indicate strong community differences within the delivery community on terms that they related to.

About 10% of the respondents provided alternative definitions. Many of these were alternative forms of the Complexity Theory definition, such as the INCOSE or Cynefin [17] definitions. Some provided added clarity to the extended OED definition with the addition of uncertainty with the inputs or familiarity of the system. These responses, principally from system engineers, support the hypothesis that producing effective definitions including Complexity Theory concepts is challenging. A few genuinely new approaches to defining these terms were also proposed that were insightful, and could be a better starting point for the definition of complexity. However, there is a concern that increasing the number of competing definitions may cause more issues. The challenge is that, despite many having strong views on what the definition is, these views are not typically the views of others.

In response to question 2, 38% provided responses that disagreed with ‘chaotic’ being more difficult than ‘complex’, ‘complex’ being more difficult than ‘complicated’, and ‘complicated’ being more difficult than ‘simple’. 17% of respondents explicitly indicated that a ‘complex’ task was easier to deliver than a ‘complicated’ task, supporting the Collins note, but countering many of the definitions of ‘complex’. This result is surprising and again underlines the importance of avoiding confusion. 44% of respondents’ answers to question 2 and question 1(e) conflicted, suggesting that the short timeframe associated with the survey drove a system 1 intuitive assessment.

Discussion

The results above indicate that there is significant opportunity for confusion around the definition of key terms, especially across communities. It suggests that the misclassification of a project as complicated rather than complex could readily be achieved due to misunderstanding the definition of a complex system.

In order to communicate more effectively when we discuss complex systems we need to either: 1) define what we mean each time with each audience; 2) avoid the term altogether, perhaps using component parts such as intricacy, unfamiliarity and unpredictability [16] and how they contribute towards making it difficult; or 3) align the definitions.

Option 1 above fails when the 'local' definition is consistently reinforced. Consequently, option 2 is the most suitable approach short term. Option 3 is a longer-term approach with four options:

a) Keep the OED definition.
b) Support and wait for the Complexity Theory definition to establish itself.
c) Extend the OED version to accommodate uncertainty.
d) Propose a new definition.

Option a) is still largely the current state. This approach is being eroded by Complexity Theory definitions; this needs to be reflected in the OED definitions.

Option b) defining complex as in Complexity Theory (hard) typically takes many paragraphs to explain, and even then it is recognized as not fixed, complex and elusive. Consequently, a commonly understood definition is likely to be evasive, even as the definition is established, unless it is substantially simplified.

Option c) has significant benefits, although it does not solve all the problems. Adding uncertainty or unpredictability to the OED definition supports the soft form of Complexity Theory definition and would allow the hard form to co-exist with the modified OED version. It essentially unifies the space with only a minor amendment. It resolves all three issues listed above, fixes the implied difference between the OED definition of 'chaos' and 'complex', and allows Chaos Theory to be considered a complex system, even though it is a unique case. The survey also suggests that the extended version is the most acceptable definition to delivery professionals.

Option d) is appealing; however, this approach, without any globally authority establishing it, would allow a swathe of competing strongly held definitions to propagate, exasperating the Complexity Theory challenges in seeking consensus, and ensuring that the other person understands you further.

Conclusions and recommendations

It can be concluded from this work that, despite the importance of understanding what a complex system is so the difficulty can be handled and mitigated effectively, the definition of complexity is confused both in literature and in practice. It can be concluded that, in the short term, delivery professionals should seek to avoid using the term as it can cause confusion. When selecting delivery approach elements it should be achieved by assessing the system to identify those aspects that lead to difficulty in delivering customer requirements and identifying techniques that mitigate those difficulty aspects.

In the long term, a range of options has been considered. It is concluded that the only option that appears to resolve the issues in the definition of complexity is to extend the dictionary definitions to include aspects of uncertainty; for example, unfamiliarity and unpredictability in the system or its inputs, leading to unpredictability in the outcome.

Further work

The definition of uncertainty, unpredictability, and emergence in the M2M, M3 inputs, system and outputs should be explored further than this paper has been able to.

In addition, it has been identified as part of this work that Chaos Theory and Complexity Theory share references to sensitivity and determinism or unpredictability. Examination of the determinism-sensitivity space in which both these definitions sit could also prove beneficial.

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Biography

Dean Beale has spent his career, principally within QinetiQ, delivering complex and difficult projects in the defence and security sector serving a variety of Government customers. These roles have included; Technical Manager, Project Manager and Systems Engineer. Dean has published over 20 papers in his fields of interest and was a Visiting Lecturer at the University of Birmingham on Project Management. Dean is currently studying a Ph.D in 'Assessing complexity and difficulty in organizational change with associated mitigation strategies' at the University of Bristol.