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Emergency and Disaster Management Requires Complex Systems Thinking and Practices

Larry M. Starr, PhD

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There are two broad classes of challenges (problems and opportunities) that may be addressed by educators in the academic and practice domain of Emergency and Disaster Management (EDM). Graduate education programs should acknowledge both kinds when formulating and presenting curricula and courses. However, the conventional approach is to treat all problems as part of a single type as if there is a one-size-fits-all premise underpinning how to think about, frame, decide, respond, and follow-up to EDM problems. I argue that a second conceptualization of EDM challenges should be formally acknowledged and added. I also argue that to adequately appreciate the second class of problems, EDM faculty and learners need to add a second mindset which will support new language, frameworks, concepts, theories, practices and understanding. This is not an "either-or" it is an "and" change, and it is not trivial. It may require reformulation of some of the cases used to illustrate EDM situations as well as reconsideration of some decisions about why certain intervention practices are appropriate. In this paper, I describe the two problem types, present concepts relevant to each, and suggest a pathway to adjust EDM curricula and courses so both are addressed in education. I conclude with cautions for this difficult but necessary endeavor.

Differing Contexts

Context, environment, and culture do not have equal meaning for EDM education and practice. The concept of context and its implications on EDM leadership and management decision making and performance may be understood and examined as a fundamental lens or framework. Everything an EDM leader thinks about and does should be considered in terms of the situation in which it occurs. The whole situation that surrounds and informs a choice or action is its context. In this perspective, operating in a military or academic or global culture, threats of illness

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and death during a global pandemic, or a sudden announcement that tap water available in the community may be toxic are *subsets of context*. Northoff[1] noted, "the concept of context is here understood in a wider way that includes different kinds of contexts, social, cultural, mental, and bodily. Culture is then one specific instance of context-dependence."

Neuroscience research[2] shows that context shapes all processes in the brain, from visual perception to social interactions which means context impacts most aspects of personal and professional experience including word and object recognition and meaning and learning abilities. Context helps people to understand cultural, social, philosophical, and political ideas, as well as actions and movements that occur when thinking, speaking, writing and performing. Context is important in behavior change, information and knowledge translation, implementation of new practices, and organizational improvements all of which are important to EDM leadership and management.

EDM leaders and managers must be reflective of how they frame problems, and how they make decisions and engage in actions depending on the context. This means instead of asking, "*What should I do about this problem*?" first ask, "*In what kind of context is this problem located*?" and "*What kind of problem is this*?" This is a change in the fundamental framework for perceiving and understanding reality. Answering these context questions helps to inform how to approach problems, how to select an appropriate method of intervening, and ordering courses of action.

The original Cynefin Framework (Figure 1a)[3] and the updated version (Figure 1b)[4] is a sense-making aid for appreciating and making decisions when confronted with differing problem contexts. *Cynefin* (pronounced Kun-Ev-In) is a Welsh word meaning *habitat* to describe distinct contexts in which a problem or opportunity exists. Contexts and problems within them may be broadly defined on a continuum of two dimensions. At one end, problems and situations are reasonably ordered (structured), predictable and linear. At the other, they are unordered (unstructured), unpredictable and non-linear. When a situation is in an ordered context, it may be described as simple, obvious and clear or complicated. When the problem context is

unordered and unpredictable, it is referred to as complex and sometimes chaotic. As described by the Associate Dean for Faculty Development and members of the Department of Emergency Medicine at the Sidney Kimmel Medical College of Thomas Jefferson University,[5]

> It is essential that curricula in health professions education help students make sense of—and take action amidst—the heightened uncertainty they will encounter in their practice…The Cynefin framework is a conceptual framework that can aid in decision-making during uncertain times and draws upon research from complexity science. The framework offers specific decision-making contexts (or domains) in which individuals and/or teams of individuals can make sense of their experiences…For simple and complicated contexts, where patterns repeat, where events are consistent, and where cause-and-effect relationships are evident and/or discoverable, practitioners should be able to navigate clinical problems through fact-based management. For complex and chaotic contexts, entirely different approaches to problem solving will be needed to emerge from the uncertainty presented in the clinical environment. The early stages of the pandemic were complex: right answers to management were not readily available; instructive patterns were emergent; leadership was pattern-based; and creative and innovative approaches were required.

Figure 1a. Cynefin Framework

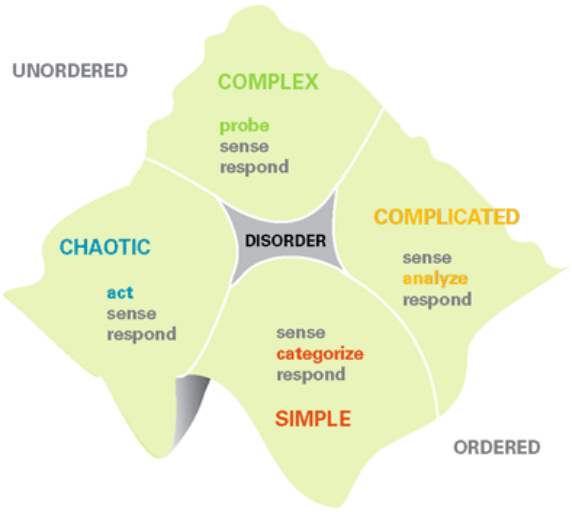


Figure 1b. Updated Language

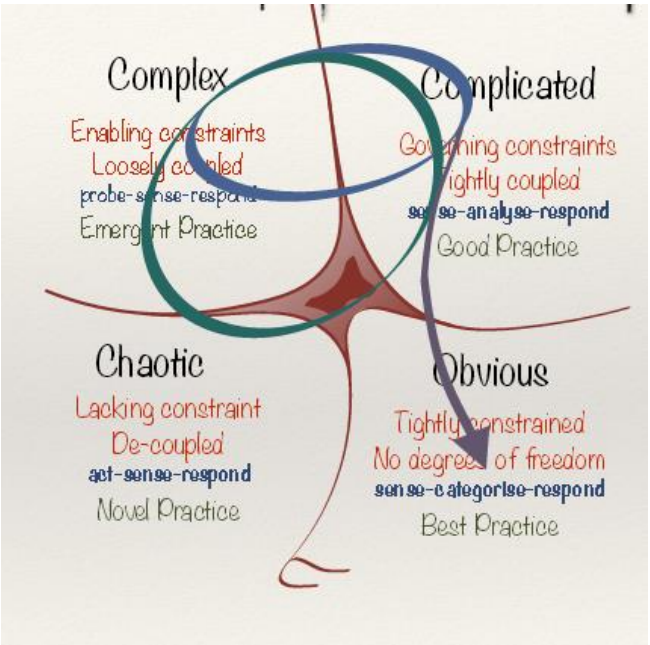
Due to differing contexts, complicated problems are qualitatively different from those that are complex. Complex problem experiences require a different mindset and mode of thinking to understand, and informed by this shift in mindset,

require different methodologies and tools to guide management choices and responses. If a leader or manager fails to recognize that a problem's context is complex or chaotic and mistakenly applies simple or complicated improvement methods and tools, these efforts will likely fail and can make the problem worse. As explained by Goldstein, Hazy and Lichtenstein,[6]

> Until recently the differences between complicated and complex were not well understood; as a result, they have often been treated in the same way, as if the same process should be used to "deal with" situations (or concepts) that are complicated or complex. Business schools justified this by treating organizations as if they were machines that could be analyzed, dissected, and broken down into parts. According to that myth, if you fix the parts, then reassemble and lubricate, you'll get the whole system up and running. But this is exactly the wrong way to approach a complex problem.

Figure 2 depicts how problems dynamically change.[3] This occurs as leaders, managers, and responders intervene with methodologies and tools aiming to shift problems from emergence and novelty to stable simplicity and application of best practices. The shifts in context require shifts in mindset, methods and tools to navigate challenges.

Figure 2. Cynefin Dynamics

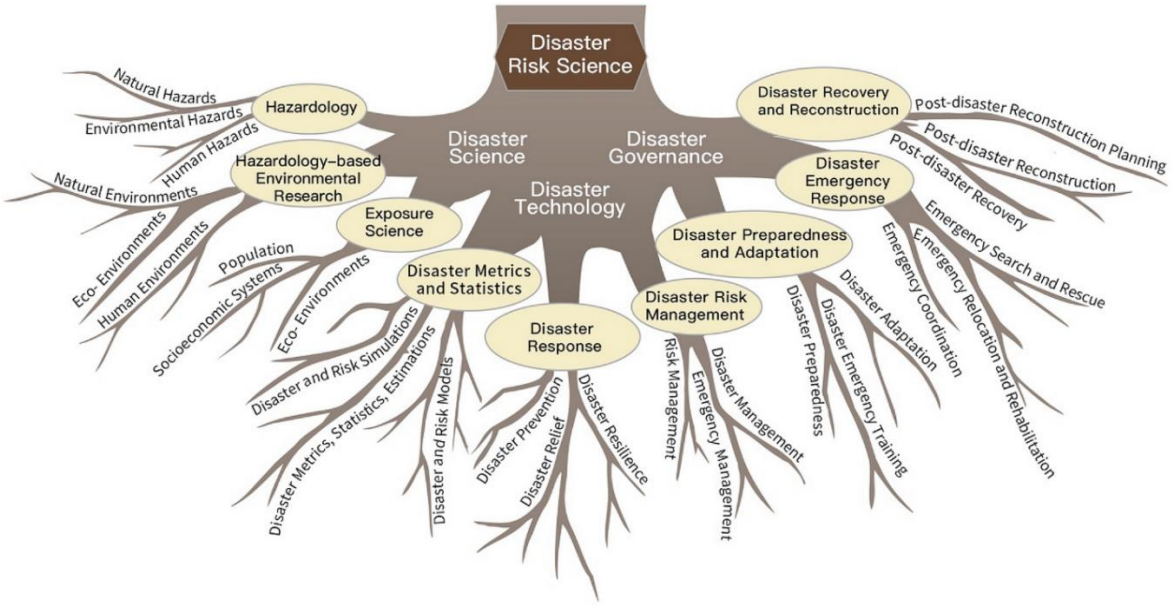


How people "deal with" an emergency or disaster is predicated on the fundamental assumptions they make about the nature of the context, i.e., the degree to which the situation is perceived to be orderly and predictable or not. To explain how different premises can inform different choices, the Cynefin framework has been applied to a variety of EDM situations including preparation and responses in case of nuclear emergencies,[7] particularly actions to be taken and avoided; cross sector collaborations to guide community response to the COVID-19 pandemic;[8] disaster preparedness and mitigation strategies in high-risk contexts;[9] complex and time-critical emergency scenarios;[10] and reinterpretation of the National Response Framework and National Incident Management System.[11] These and other relevant examples are urged to be embedded into EDM curricula and courses.

Methods of Thinking in Differing Contexts

Problems in a well-structured context that are formulated as complicated (or simple) benefit from analytic thinking. Analysis or to analyze a problem is a method of inquiry/method of thinking, from the Greek word, *analusis*, which means to break into parts. The analytic thinking mindset is that the world and the situations we encounter are understandable and so when they appear difficult and complicated, they may be effectively managed through reductionism. This posits that higher-level (difficult to understand) phenomena are derivable from lower-level elementary parts. It also posits linear causality, the notion that the occurrence of any event or situation always has a preceding and discoverable cause. This can be depicted as mechanical but more often with a biologic / organic metaphor such as roots of a tree (Figure 3).[12] Through this lens and thinking, scientists and non-scientists try to understand reality by reducing and simplifying problems into component parts and studying the behavior of those parts.

Figure 3. Disaster risk science research root system



A broad range of methods and tools have been created and can be employed to study problems from this perspective, and as a meta-methodology it has been wildly successful. Seeking root causes through reductionism over the past more than 400 years has yielded an impressive range of discoveries, technologies, and improved understanding. In health care, for example, decision making relies on scientific research and evidence-based knowledge that can be applied to understand and treat individual patients. Sackett[13] who was among the first to promote this approach wrote, "Evidence-based medicine, whose philosophical origins extend back to mid-19th century Paris and earlier, is the conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients (p.3)." EDM problems in an ordered and predictable context should be addressed using good and best-practice evidence, guidelines, and processes with the expectation that they will be mitigated and solved.

Problems that exist in unordered/unstructured non-linear contexts have been referred to as complex and chaotic, but also wicked[14 15] and a mess.[16 17] Such challenges are described[13 18] as difficult or impossible to solve because of incomplete, contradictory, and changing requirements that are often difficult to recognize. Complex situations may have no definitive formulation of the problem because due to

interdependencies, the problem is not understood until after the formulation of a solution. Furthermore, solutions generated are not right or wrong or true-or-false; they are better or worse, and emergent rather than solved analytically. As well, there are no experts for this type of problem; every complex, wicked or messy problem is essentially novel and unique and every solution is a 'one shot operation' with no given alternative solutions. Snowdon and Boone[2] described complicated and complex metaphors as follows:

> It's like the difference between, say, a Ferrari and the Brazilian rainforest. Ferraris are complicated machines, but an expert mechanic can take one apart and reassemble it without changing a thing. The car is static, and the whole is the sum of its parts. The rainforest, on the other hand, is in constant flux—a species becomes extinct, weather patterns change, an agricultural project reroutes a water source—and the whole is far more than the sum of its parts.

Confronting complexity is a special kind of individual or shared cognitive experience in response to a problem or situation where many parts interact with each other in multiple ways and where the relationship between cause and effect can only be discerned in retrospect, but not in advance. It is not apparent how or to what extent these activities are interdependent; and the environment to a decision maker appears ill-structured, dynamic, and uncertain. *Dynamic complexity*[19] emerges when what is experienced in the current reality conflicts with one's previously established cognitive map of expected patterns, structures, and outcomes. In such situations, a person may experience an inability to fully recognize, understand, feel control over or do something productive. An example of this kind of situation was presented in a narrative about a public service leader confronted with a horrific event in suburban Chicago.[2]

> In his dual roles as an administrative executive and spokesperson for the police department, Deputy Chief Walter Gasior suddenly had to cope with several different situations at once. He had to deal with the grieving families and a frightened community, help direct the operations of an extremely busy police department, and take questions from the media, which inundated the town with reporters and film crews. "There would literally be four people coming at me with logistics and media issues all at once," he recalls. "And in the midst of all this, we still had a department that had to keep running on a routine basis."

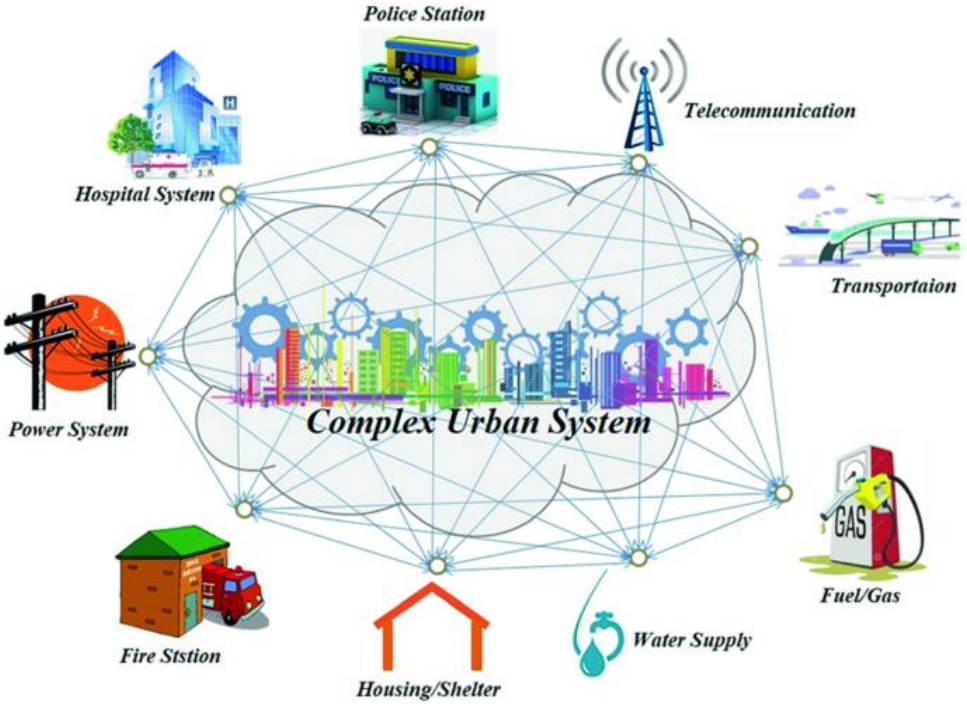
There is no way to simplify and no evidence-based approach to address the dynamic nature of this kind problem and its emergence in the context of this specific suburban community.

Jackson[20] noted, "Systems thinking as the only appropriate response to complexity (p. xix)." Systems thinking is a cognitive framework or lens for seeing, inquiring about, and understanding the world. It is an alternative to the predominant scientific and analytic framework where problems can be mechanically simplified and reduced to find clarity and to determine prime causes which when repaired or replaced generate solutions. A framework/lens acts as a predisposing mindset; it affects (facilitates or distorts) for an individual or group how data, information and knowledge are understood. When applying a systems view of the world, one is oriented not to divisible or structured disciplines or to powerful or central parts, but to whole, interconnected and socially organized systems. Social systems consisting of people are purposeful and have purposeful parts, all of which are contained in even larger purposeful systems. Systems thinking places concern on the way parts of a system interact, and, most importantly, with the conflicting or supporting purposes of the parts, the system, and the systems that contain it. When viewed through a system lens, complexity is a system of interacting problems and opportunities. Dynamic complexity concerns two seemingly opposable perceptions: holding worldview assumptions of a traditional linear, mechanistic approach that promotes understanding by reducing problems into manageable chunks, versus the evidence in the current reality where problems are dynamic, interactive, and defy reduction.

The premise of the systems mindset is that some aspects of the world and the problems that affect people and organizations consist of interacting systems which may not be understandable. The essence of this world view is that some challenges are composed of a complex set of functionally interconnected components that cannot be reduced or divided into parts without losing meaning. While the analytic mindset posits that understanding a problem derives from reductionism, identifying root causes, and is equal to the sum of its parts, systems thinking holds that the whole problem may not be able to be grasped because it is equal to the interaction of

many parts and forces and that from these interactions emerge properties, characteristics, and outcomes that may not observable or predictable from any of the parts examined individually. Systems images[21] refer to these many informing and interacting people, groups, technologies, and social systems (Figure 4).

Figure 4. Urban Disaster Management Systems



The systems thinking approach to complex problems involves framing the problem as a system and selecting appropriate systems-based methodologies and tools. These may be applied individually and in combination to describe and formulate a problem, and to guide the process of navigating and intervening to improve and mitigate it. Ramage and Shipp[22] summarize 30 systems theorists and theories noting there were “many others omitted for lack of space (p. 5)” illustrating the breadth of this epistemological approach. Jackson[23] summarized 10 in a System of Systems Methodologies table (Table 1).

Table 1. System of Systems Approaches

Systems dimension of contexts (increasing complexity)	Participants dimension of contexts (increasing diversity of values)		
	Unitary (paradigm: functional) **HARD SYSTEMS THINKING**	*Pluralist (paradigm: interpretive)* **SOFT SYSTEMS THINKING**	*Coercive (paradigm: emancipatory)* **EMANCIPATORY SYSTEMS THINKING**
Simple	*Simple-unitary problem contexts (systems metaphor: machine)* • Operations research (OR) • Systems engineering (SE) • Systems analysis (SA)	*Simple-pluralist problem contexts (systems metaphors: culture, coalition)* • Systems approach (Churchman) • Strategic assumption surfacing and testing (SAST)	*Simple-coercive problem contexts (systems metaphor: prison)* • Critical systems heuristics (CSH)
Complex	*Complex-unitary problem contexts (systems metaphors: organism, brain)* • Organizational cybernetics/ viable systems diagnosis (VSD) • Socio-technical systems thinking	*Complex-pluralist problem contexts (systems metaphors: culture, coalition)* • Interactive planning (Ackoff) • Soft systems methodology (SSM)	*Complex-coercive problem contexts (systems metaphor: prison)* • ?

Recognizing the importance of complex problems and use of systems thinking, in their *2017 Next Generation of Core Competencies for Emergency Management Professionals*, the Federal Emergency Management Agency (FEMA)[24] has included *systems literacy* as a core competency. Among the systems literacy learning objectives for Master-degree-level EDM professionals recommended by FEMA are competencies to describe the ongoing complex adaptive systems in all phases of emergency management and to support the sense-making process. They wrote,

> The emergency management professional sees the whole picture, particularly inter-relationships, and patterns of change. Systems literacy helps the emergency management professional synchronize their understanding and practice with the ongoing shift away from a linear and hierarchical human order to one that is characteristically dynamic, complex, and exponential. The focus of systems literacy is on interdependent relationships that produce reactions, changes, and adaptations over time. This scientific foundation provides the emergency management professional a deeper understanding of the present for developing future focused strategies that enable adaptation and the ability to thrive.

In their *2019 Prep Talk, Using Complex Adaptive Systems Thinking to Understand Community Interdependencies*,[25] FEMA recognized the importance of complex contexts and the use of systems thinking. They wrote,

> We find that what is written down in the plans for organizational decision making is completely different than what actually occurs in the … event of a

> disaster or emergency. Systems thinking helps to unravel the hidden interdependencies of human behavior, critical infrastructure, and decision-making in today's complex world.

FEMA's National Emergency Management Executive Academy *Course EK0680: Examining Emergency Management Policy and Doctrine*[26] is described as follows:

> FEMA's Emergency Management Institute (EMI), partnering with our Nation's best and brightest, will convey cutting edge models and approaches to the core competencies areas of systems thinking for emergency management, leading complex systems, methodologies to take ideas from inception to innovation, net centric visioning and designing, presenting for impact. The course is highly interactive and includes relevant case studies and realistic simulation exercises for emergency management executives.

The Center for Homeland Defense and Security (CHDS) recommends and teaches the importance of navigating complexity and thinking in systems. Their Systems Thinking course[27] focuses on leadership development to transform how public safety officials view an increasingly complex world and to support the homeland security mission. They wrote,

> Emergency management and homeland security professionals are continually faced with complex challenges, problems, and events. Emergency management and homeland security professionals faced with interrelated, wicked problems may be helped by the development of an ability to recognize, describe, understand, and work with their entangled and complex nature. This is precisely the focus of systems thinking and many adjoining narratives.
>
> Systems thinking also provides a wealth of tools, understanding, and language for constructively approaching and functioning within complex and entangled surroundings. The capacity of systems thinking to change perspective and inform practice is in part located in the scientific discoveries leading to its arrival.

Designing EDM Curricula

Starr[28] described a process for integrating academic curricula which addresses complexity and systems thinking, and which considers underlying theories of learning, i.e., pedagogy, andragogy and heutagogy for online and hybrid education programs. Central to this is to not merely add courses; rather, to integrate them as a "woven

rope" metaphor. Program learning objectives and learning outcomes would be woven into an integrated whole learning rope from which the individual course topics including those of differing contexts and modes of thinking appropriate to each would emerge. Based on "learning leadership," Figure 5 depicts woven concepts and content, and Figure 6 depicts how courses may emerge.

Figure 5. Concepts and Content Input

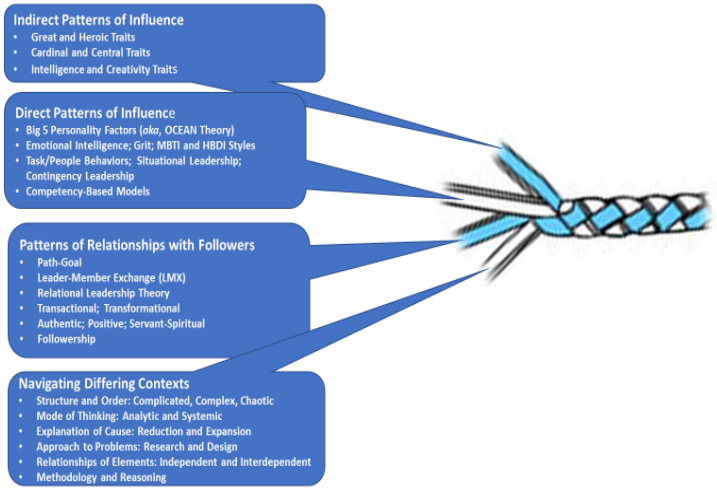
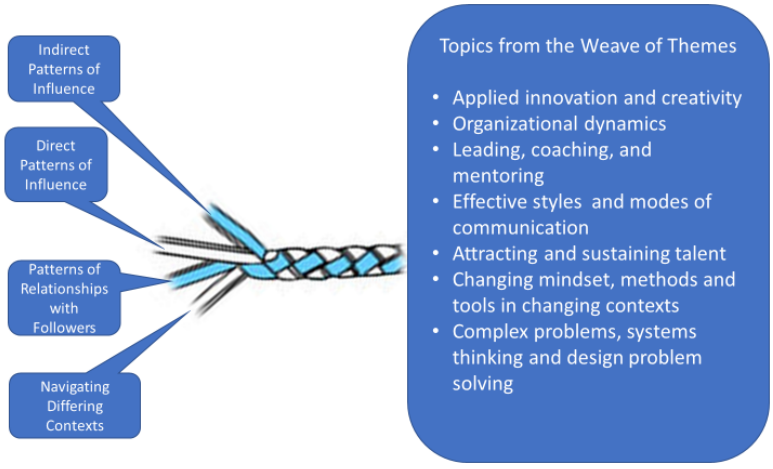


Figure 6. Developing Courses Output



In a summary of more than a dozen learning approaches drawn from multiple perspectives of pedagogy and andragogy, Picciano[29] [30] suggested that rather than

seeking a single theory for online learning, a framework would be better. He called his model, "blending with pedagogical purpose" because he applied a *blended/hybrid* approach based on andragogic theory that included the interdependent role of an instructor that was "not simply about learning content or a skill because the teacher also supports students socially and emotionally (p. 180)." His model stresses that any online course should aim to develop a *learning community* which is anticipated to emerge from the interaction of three characteristics previously described by Wenger and Lave[31] and Garrison, Anderson, and Archer.[32] One is that a single online course should have adaptive characteristics that can be extended and generalized to other courses in the same program. Another is that the course should enable multiple interactions between students and teacher, and between people and content. Third is that students should engage not only in directed learning, but they may also be supported for self-study and independent learning.

Cautions

While the amount of virtual/online content continues to increase, student/learner and teacher/facilitator characteristics interact with learning preferences and outcomes. Narain[33] reported that based on survey data, face-to-face meetings were rated by those who attend them as significantly more creative, more communicative, and as producing more shared information than meetings held virtually/online. This was supported by Bersin[34] who reported a survey based on responses from approximately 1200 business managers. He found that while virtual courses were required by 97% of respondents, it was not widely desired for learning *leadership* content. In other words, while certain content may be fully appropriate for the online context, learning *EDM leadership for complex systems problems* may be more challenging. For example, 83% of managers over the age of 35 years, and 90% of managers under the age of 35 years preferred f2f leadership learning classes. Furthermore, 71% of men and 83% of women rated f2f classes as more valuable and favorable than online leadership classes. While online learning was rated more convenient because it could be completed on one's own time (82%), at one's own pace (68%), and because travel was not required (66%), none reported that the

learning experience was better when online. The reasons why concerned the absence or difficulty acquiring interpersonal leadership proficiencies, i.e., soft skills.

Drawing from efforts by others to teach/learn systems courses[35] are the following additional cautions:

1. As the concepts of systems and complexity may be uncommon for many, they will require explanations. While those who work within the EDM community acknowledge they function in complex systems, they often do not appreciate the meanings and implications of these and related terms.
2. Academic programs require at least one and likely more teaching faculty who believe in the importance of and have proficiencies in complexity and systems concepts and practices. Co-teaching can enable improved understanding among faculty.
3. Programs that add complexity and systems into already "full" curricula must do some amount of redesigning. Adding an elective course or courses without integration will not do justice to this topic. Following a redesign process is urged.
4. Curriculum changes require education sponsorship from the highest levels including the Dean who must agree with the philosophy and importance of learning about EDM complex system and promote and provide resources to enable it.
5. Students must be engaged in learning how to adopt complexity and systems in their everyday thinking and practices. This requires use of cases and activities that demonstrate the added values and outcomes when this mode of framing and intervention are applied.

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