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Complexity in the Classroom Special Session: Teaching and Learning the Cynefin Framework by Applying it to the Classroom

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Complexity in the Classroom Special Session: Teaching and Learning the Cynefin Framework by Applying it to the Classroom

'Complexity in the Classroom' is a special session where participants will explore collaborative inquiry as a pedagogical tool by using it to simultaneously explore a systems engineering concept and course through which systems engineering is taught outside of a traditional systems engineering department. This paper lays the foundation of what collaborative inquiry is and the systems engineering framework (Cynefin) that will guide the application of collaborative inquiry in the special session. As part of the discussion, we will also provide some grounding information regarding the course the session participants will be exploring.

Collaborative Inquiry

Collaborative Inquiry is a process through which individuals work together to investigate, analyze, and test solutions to complex situations and/or problems. It has been used in many disciplines, though K12 education stands out for using this technique across teacher professional development [e.g., 1], in the classroom as a pedagogical tool in the K12 classroom [e.g., 2, 3], and as a research [4] or evaluation [5] method. Computer-mediated versions accelerated its use in the classroom [6], allowing the collaborative inquiry process to leverage both peer knowledge [7] and the ability of individuals to learn more from their data when they work together rather than alone [8]. Analyzing the variety of uses, Bell et al [9] derived a set of collaborative inquiry characteristics:

- Orientation/question – the process by which the group establishes the problem which they are attempting to solve and the evidence available for analysis.
- Hypothesis generation – the creation of a testable statement of a solution to solve the identified problem, often in terms of if-then, cause-effect, or statistical language.
- Planning – the development of the methodology to test the hypothesis, including naming the tools and evidence to be used.
- Investigation – conducting the experiment, whether it be empirical, conceptual, or a thought experiment. This investigation could be qualitative, quantitative, or a hybrid.
- Analysis/interpretation – working together to understand the results of the investigation as well as determining and controlling for biases.
- Model – the process of "building a cohering whole of objects and relations in order to represent a target area of reality, to reproduce observations from this area, to predict developments, or even to affect developments in this area". This definition is crafted to explicitly include any form of model, including prototypes, art, concept maps, sketches and graphics of all varieties, math, software, and more.
- Conclusion/evaluation – comparing the results from the model to real world situation. This is a reflective process as well as an opportunity to determine both limitations of the model and opportunities to extend and/or formalize their thinking.
- Communication – rather than a stand-alone phase, the communication element calls out the collaborative nature of the entire process. Participants bring their own knowledge and experiences, learn from those of their co-participants, and develop both their

understanding of the problem and potential solutions in collaboration with those who experience the problem in their day-to-day world.

- Prediction – one of the strengths of collaborative inquiry is its self-framing as a *cycle* of inquiry. The creation of a model and/or development of a solution is not an end, but a step along a path of continuous improvement, deeper understanding, and/or broader application.

These characteristics map to the engineering design process, thus increasing the efficacy of using collaborative inquiry in the engineering classroom.

Table 1. Overview of Activity Steps in the Special Session

Parts of the Special Session Activity	Associated Collaborative Inquiry Characteristics
Presentation of the course to be discussed, presentation of the key question for continuous improvement from the instructors, data set, and context information	orientation/question
Small groups work with the presented information to develop their own understanding of the opportunities for continuous improvement within the context and goals of the course; interpret and analyze the information in light of the key question; visual representations may be created	hypothesis generation investigation analysis/interpretation model
Each small group presents a key insight or question from its work so far	communication
Small groups return to their work with the added information from the small group presentations	conclusion/evaluation
Individuals move around the room and use sticky notes to create dialogue on, with, and between visual representations	communication conclusion/evaluation

Within the **special session** accompanying this paper, participants will explore collaborative inquiry as a pedagogical tool by experiencing it. This pedagogical application will use a variation on the collaborative inquiry technique where learners move through one or more cycles of delving into a system (collecting evidence), experience discussion guided through the Cynefin framework, and shared reflection on the meaning of the systems domain knowledge to operating and thriving in the system. Table 1 provides an overview of the activity steps and the collaborative inquiry characteristics of each step. The communication characteristic is only called out when communication is occurring outside the participant's small group.

The Cynefin Framework

Complex adaptive systems are both an important fundamental principle in systems engineering education and a reality of all engineering education. The faculty of the course which will be presented in the special session have endeavored to leverage the emergent nature of control and order in complex systems within their course design [10, 11]. As descriptions of systems are observer-dependent, this course is particularly well suited to leveraging continued development through the collaborative inquiry process. The particular framework of complex adaptive systems that we will use is the Cynefin framework, as created by Snowden and Boone [12].

The Cynefin framework is a decision-making tool that helps the engineer recognize the type of system within which they are operating and then respond in a manner that is appropriate for the cause-and-effect relationships associated with that system type. The types of system, or the domains, fall into five categories and their liminal spaces, as seen in Figure 1: obvious, where the cause-and-effect relationships are clear to everyone involved; complicated, where the cause-and-effect relationships are clear to those who have appropriate expertise; complex, where the cause-and-effect relationships are not predictable or necessarily even visible; chaos, where there are no cause-and-effect relationships; and disorder, where it is unclear what system context should be the focus.

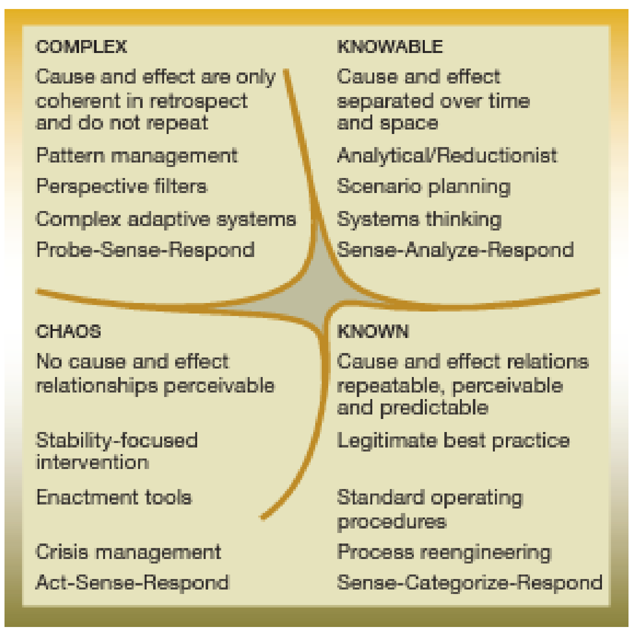

Figure 1. The Domains of the Cynefin Model [from 13]

The system we will use in the workshop is a multi-institutional course wherein participants will be able to explore how additional layers of complexity and their changing cause-and-effect relationships impact pedagogical decisions to create different learning experiences. The course, cardio-vascular engineering, is an example of systems engineering topics taught in a biomedical engineering environment. The facilitators of this special session include two faculty who have experience in both teaching systems engineering and in collaborative inquiry, as well as two faculty who are part of the creation and delivery of the cardio-vascular engineering course. The course is offered simultaneously over multiple institutions with a unified syllabus that accounts for learning needs and contexts of all the students.

Special Session and Beyond

Learning objectives for the special session include:

- Increase knowledge of the Cynefin framework of complex systems;
- Practice a pedagogical technique for teaching systems engineering concepts;
- Reflect on using systems engineering fundamental knowledge to create learning environments in different ways, particularly as the context needs of learners and industry continue to change; and
- Gain exposure to a successful course taught simultaneously across multiple institutions and student levels.

The results of the special session will be used by the course instructors as part of their on-going reflection and continuous improvement. The particular key question to be presented to the participants as part of the collaborative inquiry process will be drawn from the current status of the course evolution at the point of the special session. The broader insights from the process of using collaborative inquiry as pedagogical technique and of viewing course design and operations as a complex system will inform future papers.

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