Commentary on the Historical Contributions of Dr. Richard Cook's Realized Predictions of the Impact of New Technology on Complex Cognitive Work as Viewed Through the Lens of the Theory of Graceful Extensibility

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In this piece, we reflect on one of the most influential members of the human factors and safety community, Dr. Richard Cook. Reexamining the past is one efficient way to enhance our knowledge and advance our practice. The application of a resilience engineering outlook helps not only designers but also the units within the system to understand its capacities, especially concerning the consequences and impacts of change.

We illustrate Dr. Cook's forward-thinking concepts and add another layer of understanding and insight to his ideas on healthcare and resilience. Here, we apply the Theory of Graceful Extensibility (GE) to his predictions for implementing bar code medication administration in acute and long-term care settings. While others were celebrating and praising bar coding as the single solution to all the medication administration woes, Dr. Cook could see from a more holistic, if less rosy, viewpoint. At a time when technological interventions were thought to be nothing short of a miracle, when the true miracle is that systems work as well as they do, despite technology, Dr. Cook was able to predict various failure modes of the technological intervention implementation.

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While the current focus is on bar coding implementation, his predictions can be more generally applied to the addition of new technology into existing complex systems (O'Connor et al., 2023). Dr. Richard Cook was a man of many talents and left behind a legacy of benevolence and uncanny wisdom. He was able to notice connections that others were simply unable to.

We augment and expand Dr. Cook's realized predictions with GE, which investigates how systems can deal with surprises and maintain resilience. As we advance these original predictions, it is understood that we are not judging but assessing, analyzing, and enhancing. We honor the past while adding to it, with the realization that to ignore it is to repeat it. Newer methods and theories provide us with additional predictions for the impact of bar coding. With the application of GE, we can expound on Dr. Cook's work gracefully.

What is the Theory of Graceful Extensibility?

GE has three main underlying subsets. The first is managing the risk of saturation, the second emphasizes recognizing networks of adaptive units, and the last considers outmaneuvering constraints. GE also employs two assumptions: in the adaptive universe, resources are always finite, and change is a given. Resilience in GE considers how a system can not only function but also adapt when it is pushed to and past its boundaries (Woods, 2018).

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GE is a theory on how to create sustained adaptability in the face of change, where a system can rise to meet surprises and continue to perform, even at its boundaries, by extending capacity (Woods, 2018). Networks with hidden interdependencies can sustain longer-term adaptation. This means that one thing, such as bar coding, impacts other aspects in unplanned and unexpected ways. Here, the system subsumes some of the impacts of the change, which allows it to continue to function overall. Therefore, we may not even grasp the full impact of the bar coding implementation.

Dr. Cook's Realized Predictions

1. Efforts to maintain old ways of accomplishing tasks, and less visibility of operations.

Occurrence of Prediction: Individuals were required to use both the old and new systems, as not everyone had access to the same information in both systems. Existing process traceability was decreased by moving to the bar coding system, e.g., creating notes and carrying out medication changes were not easy to accomplish or realize (O'Connor et al., 2023).

Graceful Extensibility: Realization that tangled layered networks have hidden interdependencies, and all units have boundaries, that surprises will occur, and that adaptive capacity and risk of saturation must be managed. Additionally, it considers the ability of units to assess others' saturation risk, including the ability to synchronize across various units. Units must be ready to adapt when there is a high risk of saturation to maintain the system's capability to perform (Woods, 2018).

Enhancement to Prediction: The removal or burying of information (whose importance may not be realized before implementing a change) can harm resilience as entities must not only learn a new system, but must work harder than before to maintain functionality, which reduces adaptive capacity. An additional failure exists in not being able to differentiate between features that were simply hidden or truly removed. Here, older medication orders were removed every four hours for decluttering (O'Connor et al., 2023). With all the complexities and interconnectedness of the system, units can assist others to maintain adaptive capacity.

2. Batching of bar code scanning.
Occurrence of Prediction: Batching allows units to plan and do pre-work when they are not close to saturation. This is especially applicable to long-term care settings where some patients need significant amounts of medication (O'Connor et al., 2023).
Graceful Extensibility: When units are far from saturation, they can focus on optimality, where benefits are seen in the form of enhanced efficiency and productivity (Woods, 2018).
Enhancement to Prediction: The option of having nurse aides or student nurses assist to enhance the efficiency of the nurses was not considered. Calling in additional units to increase the nurses' adaptive capacity could enhance productivity and the ability of those units to know when others are near saturation.

3. Workarounds will be developed.
Occurrence of Prediction: Bar code cheat sheets and duplicate bar codes were created. This prevented units from having to physically scan bar codes on the medications and patients (O'Connor et al., 2023).
Graceful Extensibility: Altering the capacity for maneuver comes from modifying the interdependencies in the system. This enhances unit relationships when the risk of saturation is high. Units require a means to modify their adaptive capacity to manage the risk of saturation when circumstances threaten to deplete their adaptive behavior (Woods, 2018).

> ***Changes in one area can produce ripple effects for other areas downstream, helping us understand the dynamic complexity of systems.***

Enhancement to Prediction: Allowance of alternative methods or procedures for those patients (e.g., schizophrenics) who could not have a bar coded wristband for scanning. It can take considerable effort to get an officially approved "deviation" from the standard process. In the meantime, this may exhaust adaptive capacity and fail to meet the overarching goals of timely and accurate medication delivery.

4. Conduct of off-the-record activities.
Occurrence of Prediction: The awareness that the bar coding process created the need for various units to establish private stashes of medications to allow for quicker administration. The existing units needed new and different abilities, e.g., nurses now had to use computer mice to interact with the system (O'Connor et al., 2023).

Graceful Extensibility: The consideration that a unit's responses may be locally adaptive, while globally maladaptive (Woods, 2018). Having private stashes may increase the ability to provide medications quickly; however, the overall visibility and traceability are reduced.

Enhancement to Prediction: Awareness that a given unit's change is beneficial on a small scale but is maladaptive in the larger sense adds a crucial perspective.

Summary and Conclusions

Table 1 provides an overview of Dr. Cook's updated realized predictions with the addition of GE. We see that each realized prediction receives an additional level of complexity with the application of GE. The Theory of Graceful Extensibility considers how a system can create sustained adaptability in the face of change. Including how a system can rise to meet surprises and continue to perform, even at its boundaries, by extending capacity (Woods, 2018). We have illustrated how GE could be applied to Dr. Cook's realized predictions. The application can deepen and extend our understanding of the interdependencies, weaknesses, and strengths of the system, and how new technology can impact those.

Dr. Cook's Realized Prediction	Updated Consideration With GE
Efforts to maintain old ways of accomplishing tasks, and less visibility of operations	Systems are complex and have interdependencies, and unintended challenges can occur from alterations to previous functionality. However, units can aid others in adaptive capacity management to maintain system goals.
Batching of bar code scanning	Awareness of the units' ability to focus on efficiency when far from the risk of saturation.
Workarounds will be developed	Perceptivity that units manage their risk of saturation when circumstances threaten their adaptive capacity.
Conduct of off-the-record activities	Recognition that something may be locally adaptive but globally maladaptive, even while meeting system goals.

Our goal is to illustrate the usefulness of the application of GE to disparate systems, as these ideas can be generalized to apply to a variety of fields to form an improved awareness of how different units within a network are interconnected. GE increases awareness of how units have boundaries but can still enhance adaptability, and thus resilience.

Also, reflecting on how changes in one area can produce ripple effects for other areas downstream helps to facilitate our understanding of the dynamic complexity of systems. Viewing systems through this lens could also help with anticipating problems and working to enhance adaptability and resilience. Resilience in GE considers how a system can not only function, but also adapt, when it is pushed to and past its boundaries. The ability to recover from surprises and changes is a source of resilience.

We have couched Dr. Cook's work in the fabric of Graceful Extensibility. The ability to predict and communicate that which others were not even aware of is part of what makes SMEs and expert practitioners so valuable. One does not know what one does not know, although there are tools and methods to begin to shine a light into the void. Unabashed enthusiasm and full confidence can be indicators of overlooking potential hardships and challenges. Utilizing the framework of GE can generate valuable insights and awareness of a system's strengths, ways to enhance resilience, and to predict potential challenges and problems moving forward.

Building blocks to success can and should be taken from various fields, methods, and perspectives. Noting that technical jargon can hinder broader applicability, plainly worded and sound theories, such as GE, can be used readily in a variety of areas and circumstances. This is demonstrated here by bolstering Dr. Cook's predictions. Systems are complex and interconnected, and prone to surprises that will push their boundaries and create hardship if there is insufficient adaptive capacity or resilience available to meet them.

References

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