Kuhnian exemplars for the study of open-ended evolution

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Abstract
Kuhnian philosophy of science suggests progress in the study of open-ended evolution (OEE) would be accelerated if the research community shared a set of exemplars of scientific success. After explaining the importance of specific scientific exemplars in Thomas Kuhn's explanation of what makes normal science so productive, this paper describes five projects that would help create a set of shared scientific exemplars of open-ended evolution.

Keywords
models and measures of open-ended evolution (OEE), Thomas Kuhn, normal science, scientific exemplar

1. Introduction

The history and philosophy of science contains valuable lessons for those who seek to accelerate progress in the study of open-ended evolution (OEE). This paper describes how the study of OEE could benefit from Thomas Kuhn's philosophy of science (1962).

One of the benefits involves Kuhn's insights into scientific revolutions. Scientific revolutions change the dominant scientific paradigms in a scientific community, and they give the history of science a distinctive open-endedness. So, scientific revolutions add to the study of OEE an interesting example of real-world open-ended cultural evolution.

This paper focuses on a second way in which Kuhnian philosophy of science can benefit the study of OEE, involving Kuhn's insights into what drives progress in non-revolutionary, normal science. While the example of OEE provided by scientific revolutions could have an incremental impact on the study of OEE, Kuhnian insights about normal science could catalyze productive scientific activity across the whole topic.

The philosophy of science has typically been used to illuminate the history of established sciences. The aim of this paper is quite different: to identify practical lessons from philosophy of science that would strengthen the emerging scientific study of OEE and would catalyze new scientific progress.

2. Kuhnian paradigms and exemplars in normal science.

Kuhn stresses that the mark of genuine science and the fundamental unit of scientific change is a *scientific paradigm*. Scientific paradigms are what explain science's distinctive epistemic power. A paradigm defines the problems worth solving, provides methods for solving them, and provides concrete exemplars of their solutions.

Kuhn says that a "broad" conception of scientific paradigms would be a "disciplinary matrix" that includes key generalizations and laws, accepted models of explanation, shared scientific values, and exemplars of concrete solutions to important problems (such as precise measurements of important quantities); and those exemplars themselves constitute a "narrow" conception of paradigm (1962, pp. 182-191). The exemplars often involve tacit know-how that is embodied in specialized experimental equipment and methods, including software and other research tools and techniques. Exemplars also play a central role in training students. They are discussed in textbooks and students are taught how to replicate and extend their accomplishments.

Kuhn uses paradigms to distinguish normal and revolutionary science. Scientific revolutions are exceptional events that punctuate the usual background of normal scientific activity and sometimes lead to major novelties. During a scientific revolution, previous paradigms in the field are questioned, and no shared paradigm unifies and focuses the scientific community. By contrast, the distinctive feature of Kuhnian normal science is that the scientific community accepts the same scientific paradigm. The history of contemporary sciences is dominated by normal science, and Kuhn stresses that concrete scientific puzzle-solving occurs only during normal science. Kuhn attributed this epistemic productivity to the normal scientific community's collective focus on a shared set of exemplars.

3. Shared exemplars of open-ended evolution.

Kuhn's conclusion about the power of shared scientific exemplars imply that the study of OEE would become much more productive if the research community focused on a shared set of exemplars. Shared exemplars of OEE would provide concrete examples of scientific success. They could provide the content in OEE text books, and students would learn how to apply and extend them to solve scientific puzzles, resolve anomalies, and answer unanticipated questions.

But today no set of shared exemplars unifies the OEE community. The community contains a variety of opinions about which achievements are exemplary, and rather than applying standard OEE statistics and comparing measurements against well-known exemplary models, publications on OEE too often invent new measures of OEE and apply them to new models. Progress in the study of OEE would surely be accelerated if the community could focus on a set of shared exemplars.

4. Projects to produce shared exemplars of OEE.

If shared scientific exemplars promote productive normal science, it would accelerate the study of OEE if there were a set of shared exemplars in open-ended evolution. The following five projects are all designed to help create a set of shared exemplars within the OEE community. The projects are all feasible but they require both the leadership of a few individuals combined with widespread contributions and input from the OEE community.

Project 1: **Identify exemplary** OEE models and measures. For example, the OEE community could vote on examples of exemplary scientific achievements in OEE, and the winners could become an initial set of candidate exemplars of OEE.

Project 2: **Compare standard statistics** about OEE from a suite of exemplary OEE models. The choice of OEE models and measures would be informed by the candidate OEE exemplars produced by Project 1. The resulting data matrix would be the systematic and comprehensive attempt to map of the current combination of achievements in OEE. This paper could become a landmark that both motivates and helps identify future progress; the paper could even become a Kuhnian exemplar of OEE. Comparisons across the matrix should certainly help identify many good candidate exemplars of open-ended evolution.

Project 3: **Produce a review paper** on OEE. The review would survey and evaluate the important scientific achievements and open questions about open-ended evolution. This would highlight exemplary OEE achievements and exemplary models and measures The comparison of many measurements across many models from Project 2 should contribute valuable content to the review. The scope of OEE is broad enough to perhaps merit two or three reviews of different aspects of the subject.

Project 4: **Produce a tutorial** on OEE. This tutorial could be presented regularly at Artificial Life meetings. The review papers on OEE produced by Project 3 could provide background reading for the tutorial. The tutorial could also distribute code that makes it easy for students to calculate a number of standard OEE statistics in a number of exemplary OEE models. The

Project 5: **Produce a textbook** on OEE. The results of all the previous projects should contribute substantially to the first draft. The text could cover the comparison of models and measures produced by Project 2, and the OEE review papers should contribute content to most of the text's chapters. An especially empowering addition to the text would be a digital data repository with all the resources that enable people to make many standard measurements of OEE in many exemplary models.

5. Conclusions

Insights from Kuhnian philosophy of science suggest that one of the best ways to accelerate progress in the study of OEE would be to create a set of OEE exemplars that are shared by the OEE community. Shared OEE exemplars would motivate and model exceptional success in the study of OEE, and this would promote scientific productivity and progress. This Kuhnian analysis emphasizes the collective activity of the scientific community. Excellent scientific achievements of individual scientists are not enough to fuel science's distinctive epistemic power. That power depends on a research community sharing the same paradigm and agreeing on the problems worth solving and the methods worth using.

This paper proposes five projects that would contribute to the creation of a set of shared exemplars in the OEE community. The projects would identify an initial set of candidate shared exemplars and systematically compare them, and then evaluate how the exemplars might be adjusted. Further winnowing and tweaking of the exemplars would be achieved as review papers, tutorials, and text books are produced. In a few years a well-studied set of shared exemplars of OEE should fuel the productive scientific activity that characterizes Kuhnian normal science.

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References

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