GENERAL ARTICLE

Novelty and Utility

How the Arts May Advance Question Creation in Contemporary Research

JOHANNES LEHMANN, RACHEL GARBER COLE, AND NATHANIEL E. STERN

ABSTRACT

This paper builds on research around novelty and utility to argue that the value of arts thinking should be applied in the generation of scientific questions. Arts thinking is often playful, less goal oriented, and can lead to new modes of questioning. Scientific thinking often solves an existing question, serves a purpose in solving the question, and must be predictable. The "problem of the problem" is that asking creative questions is the linchpin of the quality of research across the sciences, just as the best of art "does things" that make us move and feel moved; yet we posit that it is useful to consider that what each teaches and celebrates typically tends more toward *either* utility or novelty as an entry point. A new theoretical basis is presented in identifying questions primarily based on novelty rather than utility, and a catalogue of methods proposed for creating questions to employ in education, practice, and project planning.

THE PROBLEM OF THE PROBLEM

Identifying a creative question is the first step in creative thinking [1–3] and arguably the most important step in the creative process in research [4]. It is also the most difficult and the most neglected in institutional science approaches [5] and has not been examined until the 1960s [6], and it is concerning that research on question creation appears to have slowed in the recent past [7]. We argue that to make any headway in solving this "problem of the problem," we must understand how different modes of thinking work across art, design, engineering, and science [8,9], or rather how institutions determine the ways we ask questions. We introduce the continuum between novelty and utility to frame thinking and the connection to creating questions and finding problems.

In natural science and engineering, students typically are graded on their reproduction of knowledge already familiar to the instructor [10]. The research or educational process typically does not include projects that solely or mainly focus on creating questions [11], nor are projects generally funded if they do not posit a question that has been identified from the outset. In fact, instructions on scientific methods almost always start with a question, and major textbooks on scientific methods traditionally claim that "the student . . . has no difficulty in finding a suitable problem" [12]. Much of scientific proposals and education then revolve around methods to solve the question [13], rather than proposing ways to create questions within the context of what is already known.

In comparison, educational and professional activities in the artistic and design realm focus on creating and identifying a question or problem (Fig. 1). Artists prioritize the quality of how they question assumptions, perceptions, behavior, and conclusions [14,15]. They experiment, play, and take risks; think and rethink; problematize and reimagine [16]. Designers, too, focus on problem-setting, almost always from the perspective of a given person or people with whom to empathize [17].

In this paper, we lay out the transformational potential for discovery in the sciences and engineering by developing the theoretical underpinning and approaches for creating questions in science and engineering education, in addition to evaluating and assessing projects and proposals through the lens of artistic practice. We thus hope to chart paths for a meaningful collaboration between art and science.

MODES OF THOUGHT

Designers define problems, scientists and engineers solve problems, and artists create problems to "discover ideas, problems, thinking, and relations that cannot yet be articulated or solved," so as to "bring people there, both the general public and specialist researchers, to see, and feel, and say previously unsayable things that might lead somewhere new, again" [18]. Artists revel in good questions—and less often worry about answers—precisely because they want to share those questions with their audiences, who will go forward thinking and feeling, experimenting and testing.

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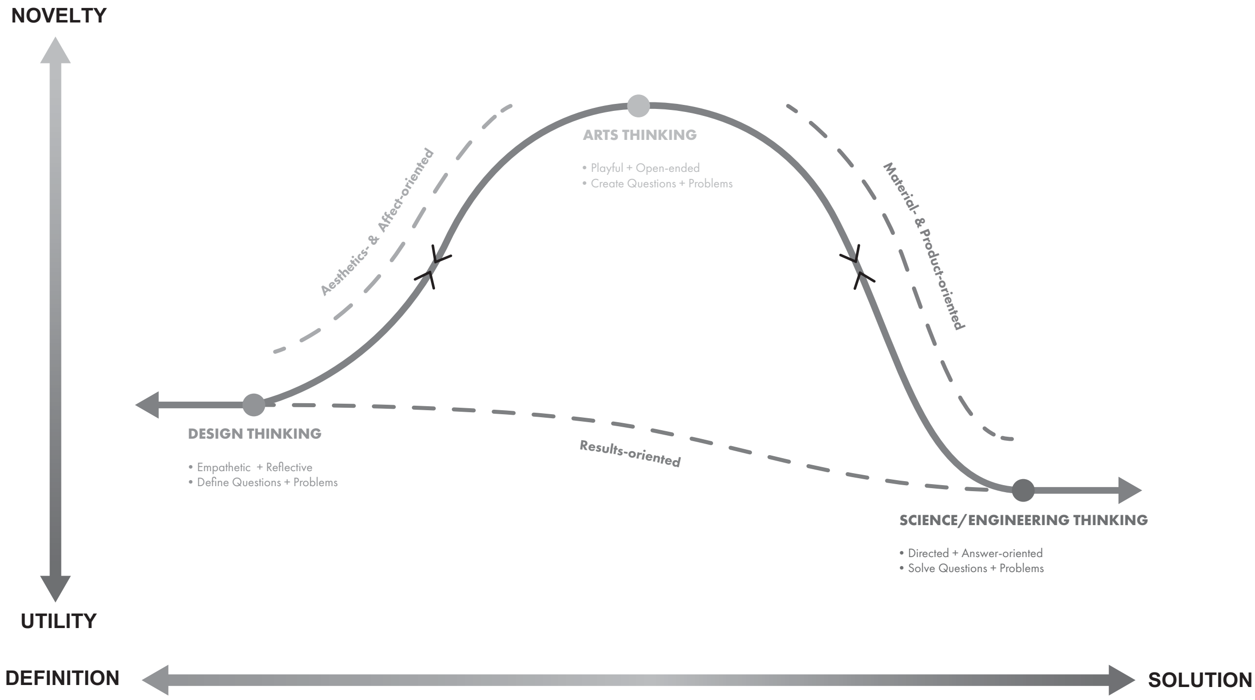

Fig. 1. Proposed illustration of relationship between art, design, and science thinking in prioritizing either novelty or utility as an entry point to creating questions. Utility here describes focus on solving a question and makes no statement about for example basic or applied science. Ideally, utility and novelty are both achieved when creating a question, while priority may be given to one or the other in a nuanced way.

Here, a distinction between process and outcome is vital. For example, the most defining trait of "Design Thinking"—popularized by Stanford's D.School—is that it is empathetic and user-centric. It is a "methodology for creative problem solving," which begins and ends with understanding and defining a specific person or group's needs and wants [19]. The result—a designed product—*serves* that person or community.

Science and engineering, too, have concrete processes that differ from their outcomes. Scientific outcomes tend to be knowledge-based, and engineered objects serve a purpose. Both processes are linear—albeit often iterative—include trial and error [20], and must arrive at a result or product, not simply another question. In science, questions are conventionally asked first, with hypotheses posed, then tested [21], despite the occasional calls for abandoning the scientific method [22]. In engineering, specific problems should be solved by products that require various specifications; solutions are brainstormed and graded, prototyped, and iterated toward a final product. There are, of course, a wide variety of individual approaches in all these disciplines, and the mentioned typologies are understood as the most prolifically taught institutional starting points, even if they do not reflect the panoply of individual responses.

Finally, arts thinking is even less well defined, and the "purpose" of art objects may vary from artist to artist, art scene to art scene, art movement to art movement. Whether a piece causes dialog and debate, or changes trajectories of thought and discourse, each of these creates different types of value for different audiences. "The question is not, What does this artwork *mean*? It is, rather, What does this artwork *do*?" [23]. In that vein, Ruth Catlow asserts:

> Artists . . . can tolerate, even relish, extended encounters with difference, contradiction, muddle and slippage between symbolic and material possibilities without rushing to usefulness or simplicity. . . . They know that a way to get to know something that doesn't exist yet is to collaborate with its possibilities and do something / anything with it or about it [24].

Similarly, philosopher Erin Manning calls for a "Pragmatics of the Useless," with arts thinking among "useless" things. It is understood that "what has a use in the future, unforeseeably, is radically useless now" [25]. Following mathematician and philosopher Alfred North Whitehead, art is not utilitarian but rather an "adventure toward novelty" [26].

These modes of thought—not outcomes—for art, design, science, and engineering may be illustrated across a continuum from utility to novelty and from definition to solution (Fig. 1). Here, arts thinking is shown as the most novel, placed between definition and solution; design thinking focuses most on definition and tends toward utility; science and engineering are the most utilitarian and the most solution oriented. We propose that the slopes between these simplified "points" be further defined, where art and design are aesthetics- and affect-oriented, art and engineering material-oriented, and design and engineering results-oriented.

These relationships may help to illustrate the problem (of the problem) and the thesis of this paper, as well as address it. For novelty to be produced, we argue, utility must be de-prioritized, at least temporarily. Novelty and utility are thereby *not* a dichotomy, but we do need institutional amplification of each to achieve both.

CONFRONTING THE AUDIENCE

Art in its many forms—visual art, performance art, conceptual art, music, and literature—activates questions as a way of bringing an audience into dialogue (Box 1). In artistic disciplines, knowledge is built not only from what the artist knows but also what the artist does not know. Often it is the act of art-making that generates questions. An artist may begin with a set of materials, and to a large extent it is in the exploration of those materials that inquiry and meaning are revealed [27], which exploration also includes a good deal of chance [28]. The view is therefore ubiquitous and disordered, and the activity can be described as playful or even risky (Fig. 1). In this way, to "think differently than one thinks" [29] becomes a possibility. As Buckminster Fuller put it, such intuitive probing or thought allows for new scientific frontiers [30].

Arts thinking is, in a single pun, undisciplined. Using design thinking and applying arts thinking, we ask, "How might we 'undiscipline' scientists and engineers to help them ask novel questions?" [31] We present two examples of artists working more directly with functions of questions that demonstrate the opportunity for artistic practice to move this discussion forward: one project by Rachel Garber Cole (Fig. 1) and a prototype by Nathaniel Stern (Fig. 2).

Cole's *Questions for a Dinosaur* project brings new insights into the psychological experience of living in climate crisis by asking a dinosaur 106 questions about extinction (Fig. 1). While the dinosaur provides no answers, the questions themselves, taken as a whole, articulate a collective experience of eco-anxiety [32]. The remixing of available information and data [33], as done by Cole, allows examination of new viewpoints.

Stern's *Question Machine* remixed data in a different way (Fig. 2). The *Question Machine* can be a computer program or an analogue device as much as a group activity that generates questions but no answers. When imagining a question machine whose sole purpose is to generate novel scientific questions, the scientist is likely to ask, "What criteria are used to prioritize or filter such questions?" Here, innumerable possibilities exist, such as the use of textbooks, grant proposals, or Internet sources. For example, the artist collective Dumb Type recently presented *2022*, a project at the Venice Biennale that projected simple and universal questions generated (via machine learning) from an 1850s geography textbook without offering answers [34].

Following these two examples presented by Cole and Stern, we posit that jumping straight to utility to solve a question, as is done habitually in the sciences [35], limits the possibilities presented by the new. The requirement of utility stifles novelty at the outset. Utility must be put aside, at least temporarily, so that the most unique questions can be created in the first place, without precondition. Such a process is playful, experimental, and, for the uninitiated, seems risky or even a waste of time. But when exploring something new, wasting time is never a waste of time [36]. As the inventor and chemist Stephanie Kwolek noted, "All sorts of things can happen when you're open to new ideas and playing around with things" [37]. Notably, Alexander Fleming's response to what the key elements of his research were that led to the discovery of penicillin was that he was not doing research at all; "he was just playing" [38].

Once questions are articulated, they may be vetted to move from novelty to utility. The continuum of processes shifting between utility and novelty is in our view important to

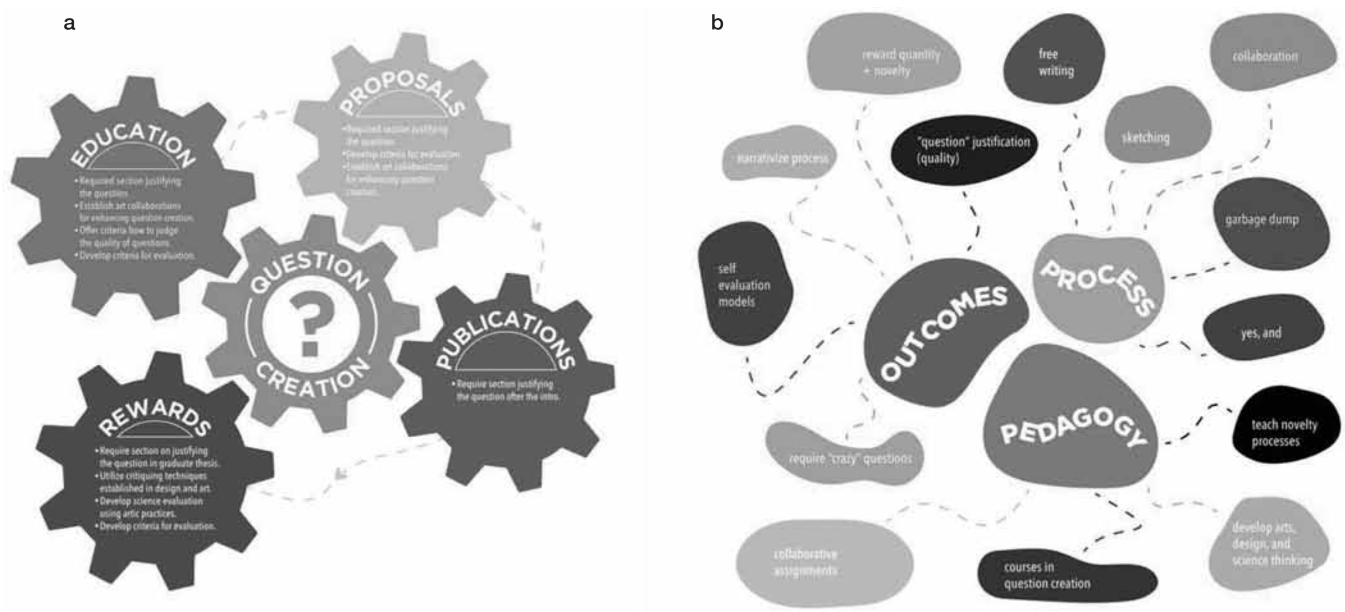

Fig. 2. Strategies to make question creation a driver in research: (a) Rendition conceived by a scientist shows cause and effect, where different strategies are employed in education, proposal writing, publishing, and rewards drive, and are driven by question creation. (b) Rendition conceived by an artist (initially with free writing, sketching, and Post-It notes) that branches out a spray diagram from the potentials of process, outcomes, and pedagogy.

explore, and artistic thinking and practice can provide approaches that are different from those typically used in the sciences. The *Question Machine* (Fig. 2), for example, can generate classes of questions grouped by their novelty and utility, with intriguing juxtapositions.

At the beginning of an artistic process, the result is rarely fully articulated. The engagement with the environment, materials, and thoughts [39] generates the path toward a question. Establishing a distinct phase of scientific pursuit in which the scientist creates questions rather than answers may benefit from borrowing thinking and techniques from artistic practices. It also enables a proactive inclusion of ethical or political aspects [40] that undeniably are connected with scientific pursuit yet are often not part of creating questions.

CHANGING THE AUDIENCE

Artistic practice is a platform suitable not only for confronting an audience with the challenge of wrestling with questions but also for engaging the science community in a more elastic approach to formulating questions. Several techniques can be found in arts-based research in the social sciences [41,42]. In addition to the more familiar focus groups or retreats, such techniques include improvisation [43], associative free writing [44], metaphors [45], or dreaming, among others. Even if just a story, the account that the discovery of the benzene ringby August Kekulé that ushered in modern organic chemistry was associated with a dream of a snake seizing its tail [46] suggests the importance placed by creative individuals on a diverse set of circumstances that may catalyze insight [47]. Design thinking utilizes spray diagrams, design walks, brainstorm cards, stokes (playful introduction of topics), empathy interviews, and various other approaches. In comparison, arts thinking plays with free sketching, garbage bag dumps, perspective shifts, folding in music, space, politics, matter, and more. The playfulness of engaging with environment and materials generates experience in art [48] that can generate new questions.

We are less interested in precise instrumentation and more in affective possibility, which is precisely where arts thinking lives. When scientists engage in diverse activities and productively challenge their own subject matter assumptions at the onset of an experimental process, before a question or hypothesis is formed, scientific advancement can move from uncovering the "known unknowns" to examining the "unknown unknowns" [49]. It is frustrating, time consuming, and feels silly at times, but being undisciplined in this way is potentially disruptively productive.

CHANGING THE STRUCTURE OF RESEARCH

Through the preceding examination of art practice and thinking, several opportunities to prioritize question creation in science arise that can generate a deep and meaningful collaboration between artists and scientists. These range from developing proposals or writing up scientific results to science ranking and reward structures or educating students. Using our own model of collaboration and recognizing powerful connections between form and meaning [50], these connections were conceived both as a cause-and-effect diagram, centered around question creation as a driver (via science thinking), and an ongoing spray diagram, branching out from outcomes, process, and pedagogy (arts thinking) (Fig. 2).

Writing science proposals typically focuses on justifying a set of questions that intellectually anchor the planned study. Imagining a scientific project where a major part or the entire proposal promises identifying rather than solving a question is a structural shift in the academic landscape. When we asked a science program in the U.S. National Science Foundation to consider "inquiry-based science-art partnerships to focus on developing questions rather than focus on answers . . . the objective of the proposal being the development of a question, using practices developed in the arts and humanities," the program officers could only respond that it may be "worth reaching out to program officers in the Social, Behavioral, and Economic Sciences Directorate at NSF" (correspondence March 2020). Clearly, scientific projects are supposed to start with a set of questions. Here, we suggest building question creation into grant applications using the following approaches, to be spelled out by funding agencies in their requests for proposals: (1) require a section outlining the quality of the question, with explicit reference to creativity; (2) develop a catalog of criteria that the applicant needs to meet in creating questions; (3) develop a list of criteria regarding the quality of questions, against which the application will be judged. In addition, collaborations with artists may be established as a standard practice [51], albeit one to be carefully planned by recognizing the differences in practices, funding, and reward structures between art and science [52]. Charting an explicit path toward question creation as part of a project provides the opportunity for new research directions [53].

Scientific publications should include an opportunity to identify the creativity of the question. One approach may include establishing a separate section after the introduction that justifies the question and specifically addresses how this question stands apart from those that have been asked to date with respect to novelty. The guides for authors of scientific journals typically focus on the sequence introduction-method-result-discussion-conclusion, without an explicit mention of the question or its justification. The introduction implicitly serves this purpose but often focuses on introducing the topic and its importance rather than the specific question [54]. A separate section called "Justification and development of the question" placed after the question provides a more visible opportunity to address this shortcoming than the commonly included justification of the topic. Including well-founded and novel questions as part of the results of a publication may generate more compelling and agenda-setting science communication. These may be called out in a separate section as part of the discussions section, e.g. "Questions created."

Important changes should be made in education [55]. Building question creation into education is one of the most formidable and most rewarding challenges. Contemporary educational curricula are practically devoid of courses or modules explicitly designed to create questions, despite advances made by arts-based research in social science education [56,57]. Science courses should (1) let students come up with a science question; (2) develop templates for what question creation would look like; (3) develop a method for how students would go about this discovery process, such as through "yes-and" [58] and other improv techniques that continue rather than stall the creative process, including "reverse thinking" techniques [59]; and (4) develop a list of criteria for how submissions are judged. In addition, course modules as well as dedicated courses should be designed specifically to focus on questions in natural science curricula. Artistic practice may provide a platform for activities to create the questions, including workshops that engage full body senses, automatic free writing as a mode of brainstorm, and unstructured quiet time [60]. These artistic practices are meant to free up the mind from routine thinking and achieve more elastic processes for knowledge production that make use of up-to-date insights from neuroscience about the importance of the unconscious in decision-making [61]. The key is to conceive the organization as an "assembly point of acts" rather than an "assembly point of ideas" [62] to prioritize the educational experience. An important aspect is the satisfaction that students experience when they are in the driver's seat of creating an exciting question, as mood in general plays an important role in question creation [63].

Rewarding the quality of the question, rather than only the answer, is implicit in the reception of the science product but only rarely given the prominence it requires. We propose the additional requirement for a separate section as part of graduate theses on the quality of the question written early in the degree program. We believe this may significantly improve the way students reflect on the importance of creating questions. It may also be productive to employ a practice of critique, much in the same way students engage with each other's work at art and design schools. Artistic reflections on the question itself may be a suitable approach to evaluating its scientific creativity.

OUTLOOK

With the plethora of complex challenges that humanity faces, it is necessary to begin asking not only questions that we know but also questions that we do not know. Rather than starting the inquiry with "What should we do?", we must focus on "What should we ask?". This shift will take an unprecedented "undisciplined" approach to thinking and problem-solving in the sciences to become aligned with art thinking. Such questions must initially prioritize novelty over utility by engaging with materials and audiences. The exciting step for art and science is then to jointly build bridges between novelty to utility by reexamining institutional frameworks of reward structures and education.

APPENDIX 1: *QUESTIONS FOR A DINOSAUR*

BY RACHEL GARBER COLE

The multidisciplinary art project *Questions for a Dinosaur* exemplifies how the process of generating questions can lead to a form of knowledge building. In the piece, Cole asks a dinosaur 106 questions about extinction (Fig. 3). The questions swing from the direct ("Are we currently living through a mass extinction, in your professional opinion?") to the material ("Should I buy a gun?") to the absurd ("Have you seen the movie *Melancholia*?") to the existential ("How do you adequately mourn the death of a planet?"). Despite the onslaught of questions, the dinosaur—who by all accounts should be an expert on the subject—answers none of them. The conversation, then, is in the questions themselves and in the way they

Fig. 3. Rachel Cole during her performance *Questions for a Dinosaur* at the School of Integrative Plant Science at Cornell University on October 25 2019 (left; https://events.cornell.edu/event/questions_for_a_dinosaur) and a print from the portfolio of 106 prints in collaboration with Lane Sell and photographer Jordan Levie (right). (© Rachel Cole)

articulate ways of understanding how anxiety, expectation, privilege, and comfort play into how we as individuals, psychologically and behaviorally, respond to the climate crisis.

During two performances of the piece at the School of Integrative Plant Science at Cornell University, the disciplinary differences in the sciences and art practice came into focus. Spontaneous reflections among students and faculty generated discussions on how the institution may provide more opportunities to ask better scientific questions, and students argued for inclusion of question creation in curricula.

Within the context of a scientific institution, the *Questions for a Dinosaur* performances therefore triggered conversations around how knowledge is produced, communicated, and defined, and how the sciences might use these artistic practices to inspire new ways of approaching the discovery and collection of knowledge by centering on the act of scientific *questioning*.

APPENDIX 2: *QUESTION MACHINE*

BY NATHANIEL STERN WITH JOHANNES LEHMANN

Question Machine is a thus far only prototyped art project, born out of conversations between a philosopher, an engineer, art historians, artists, and a scientist. Here, the artist made metaphorical garbage bags of scientific terms, concepts, actions, and attributes (supplied by a scientist, from his field of soil science) to dump on a metaphorical table and make something new. The software randomizes combinations of these terms to generate questions, without worry over the utility in the questions it generates (Fig. 4, left).

They began with the question: What if there was a machine with the sole purpose of generating novel scientific questions? For now, the machine uses pseudo-random numbers to pick from lists of words in a pre-set order. While this removes the affect and aesthetic sensibilities of the artist—which also contribute to material play—it also removes the will toward utility of the scientist.

Is there a mechanism for question-setting that is reproducible? Is finding a good question a process, something that can artfully be designed? Might the uselessness of randomly generating scientific questions prove useful in the end—even if only in the dialog its outcomes generate? If not, what information could be fed into such a machine, what processes developed, to produce more potential in its novelty? How important are the number of questions in comparison with the utility and novelty of the questions that are generated?

The project spotlights the "problem of the problem" to provide a platform for inquiry across disciplines and modes of thought. It requires a handshake between science, engineering, design, and art. Can question machines catalyze such a handshake, and what would a more refined platform look like? What might be produced from a project where artists are asked to develop question machines, where designers and scholars in the humanities are asked to define the problem, and where scientists and engineers experiment with different solutions that move from novelty to utility?

As part of workshops and classes at Cornell and Binghamton Universities, we asked participants consisting of students and faculty, to build question machines (Fig. 4, right). The ensuing conversations about the structure of questions, what information goes into a question, and how to evaluate the novelty and utility of a question lay the groundwork for a long-term incentive to scrutinize question creation as a topic.

Stern and Lehmann are now working with AI poet Sasha Stiles on a *Neural Network-based Question Machine*, built on GPT3 (an artificial intelligence framework by openAI). Here the machine will not learn what makes a *good* question but rather what makes a question at all; and it will be trained not only on scientific hypotheses from Lehmann's Lab but also on poetry, philosophy, arts criticism, and the social sciences (for example), toward both novel—and, we hope, eventually—utilitarian ends.

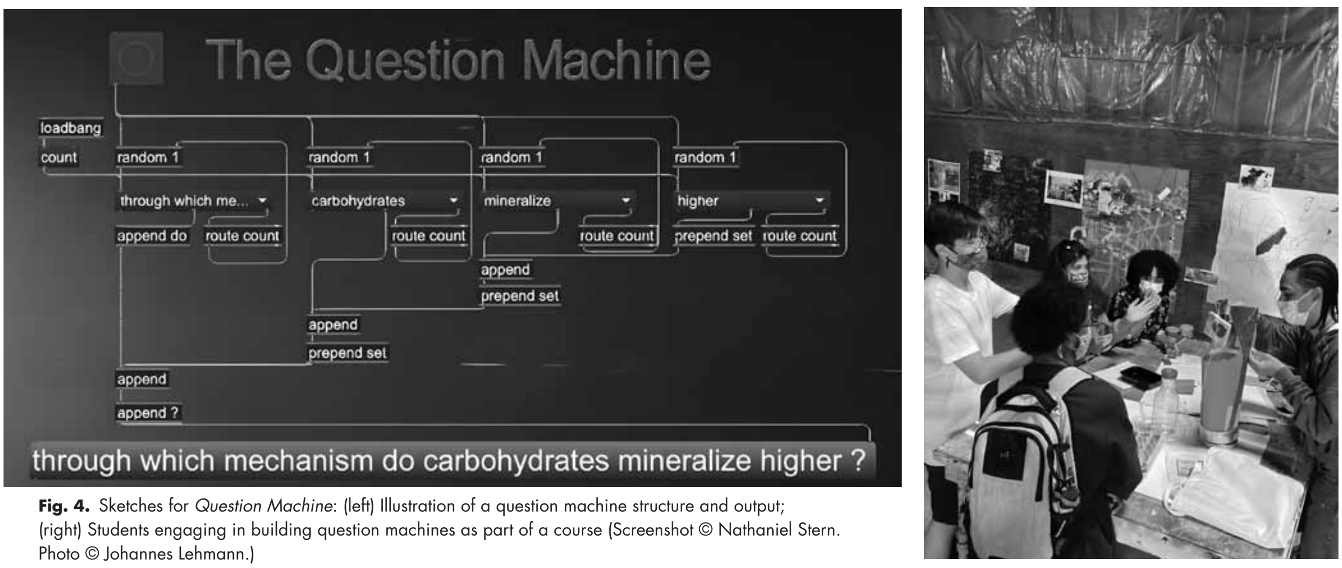

Fig. 4. Sketches for *Question Machine*: (left) Illustration of a question machine structure and output; (right) Students engaging in building question machines as part of a course (Screenshot © Nathaniel Stern. Photo © Johannes Lehmann.)

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