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A community science model for interdisciplinary evolution education and school improvement

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Abstract

A generalized conceptualization of evolutionary processes allows for a view of the cognitive, behavioral, and cultural variation in our everyday lives as elements of diverse evolving systems. Such a view invites questions about how cultural evolutionary processes may favor or hinder the expression of variant thoughts and behaviors, any of which may be more or less valued by any given community. From an educational perspective, this implies an untapped potential for engaging students in understanding the cultural evolutionary dynamics of their everyday lives, schools, and broader communities. As a strategy to engage this potential, the Community Science Lab at the Max Planck Institute for Evolutionary Anthropology is developing a unique model of *Community-Based Cultural Evolution* (CBCE) for inter-institutional collaboration at the intersection of evolution education and applied school improvement efforts. Using advances in teaching for conceptual understanding and transfer of learning, the CBCE model aims to empower students to clarify, investigate, and collaboratively influence the cultural evolutionary dynamics of their own school and surrounding communities. The relationship between students' evolving intuitive theories of school improvement, and the evolving scientific theories of school improvement scientists, provides a framework for understanding the development of student conceptions of cultural (and, perhaps, biological) change more generally. This chapter provides a conceptual foundation for exploring the claim that engaging students in reflecting on the cognitive, behavioral, and cultural evolutionary processes in their everyday lives provides new opportunities for school improvement and interdisciplinary evolution education initiatives. The practical and systemic challenges of this approach are clarified and future directions are outlined.

Introduction

A significant trend in 21st century educational innovation is to involve students and other stakeholders (teachers, parents, community members) in the participatory improvement of school design (Mintrop 2016). An obvious question in such initiatives would be: what skills do such stakeholders need in order to effectively engage as participants in school improvement aims? For many education leaders, the answer to this question may take the form of broad competencies such as critical thinking or social-emotional learning. Apparently missing from this current discussion, however, is consideration of the conceptual understandings that different stakeholders might have in regards to the nature of human learning (and human behavior, cognition, or culture more generally) within present-day societies. That is, current work in participatory school improvement overwhelmingly lacks frameworks or resources for deep engagement with stakeholders about big questions regarding the origins and purpose of schools in society and the relationship between schools and the human condition. In this chapter, we argue that generalizable evolutionary concepts may be practically helpful for the aims of supporting community-based approaches to school improvement, especially when embedded within an interdisciplinary evolution science curriculum.

First, we provide a brief review of the state of the art in thinking about evolutionary concepts as related to school improvement. Here we describe that while the field of evolution education has not significantly engaged with evolutionary perspectives on learning, teaching, or schooling, the

field of educational psychology has developed a diversity of often disparate and possibly incongruent evolutionary conceptualizations for school improvement.

From this brief overview, we then highlight our aims and early work in establishing a community science model for applied educational design research in this space, which we call *Community-Based Cultural Evolution*. We then present the Evolving Schools project as an exploratory example for organizing school-based research collaborations. We conclude with challenges and future directions.

Evolutionary concepts in school improvement

Educational thinkers, from across cultures and historical periods in which schools have existed, have commonly thought about teaching and schooling in relation to some conceptualization of the human condition more broadly. With the emergence and popularization of Charles Darwin's work concurrently with the rising global trend of universal formal schooling, it is perhaps not surprising that even early influential educational theorists such as Maria Montessori (see Frierson 2018) and John Dewey (see Popp 2012) worked intensively to contextualize their thinking within the evolutionary science of their day. While education and evolution sciences have significantly diverged during the 20th and 21st centuries, there remains a complex, if highly fragmented, relationship between these fields. This complexity and fragmentation may also drive the diversity of views on how education and evolution could or should be related. The scope here is not to provide a comprehensive overview of this diversity, but only to characterize and briefly highlight some examples across the fields of evolution education and school improvement as a context for our more integrated approach.

The view from evolution education

It is uncontroversial to describe that the topic of *school improvement from an evolutionary perspective* is not on the radar for the international field of evolution education, which is a sub-field specialization of science and biology education. Specialized journals including *Evolution: Education & Outreach*, *Science & Education*, *Journal of Biological Education*, and *The American Biology Teacher* have limited relevant literature on record (the only even partially relevant examples we have been able to find include Gray 2011; Grobstein & Lesnick 2011; Eirdosh & Hanisch 2020). This is not surprising, as the field of evolution education overwhelmingly lacks a focus or research infrastructure for engaging general education students in the evolution of human behavior, cognition, and culture, more generally (Ziadie & Andrews 2019). It is beyond the scope here to explore the reasons why this may be the case, historically and conceptually (see Hanisch & Eirdosh 2020a for relevant discussions), only to point out that it is the current status quo. This is an important context, as our community science model includes an explicit emphasis on the conceptual content of evolution education as a driving support for student participation in school improvement.

Diverse traditions of evolutionary theorizing in school improvement

While evolution education may not engage with broader school improvement aims, educational psychologists and school improvement scientists have significantly engaged biological and generalized evolutionary theory as contexts for developing educational theories. Similarly to Nettle's (this volume) more general contextualization of evolutionary theory in psychological sciences, we have previously argued that all of educational theorizing is evolutionary in some sense (Eirdosh & Hanisch 2020b). The question, therefore, is not so much *if* a theory is evolutionary, but in what ways does it engage evolutionary concepts, and to what scientific and/or practical benefit?

Below, seven popularized theories or frameworks are concisely summarized, without analysis or judgement as to the scientific merits. The aim of this section is only to briefly highlight the diversity and largely fragmented state of evolutionary theorizing in educational research and school improvement literature. Overall, it should be noted that educational theory currently involves the application of generalized evolutionary concepts, especially within traditions of *Cognitive Load Theory*, *Prosocial Schools*, and *Networked Improvement Communities*.

***Biologically primary and secondary learning*.** Evolutionary educational psychologist, David Geary (2005), has outlined an argument for distinguishing between domains of learning that humans have plausible (genetic) adaptations for acquiring through automatic, intuitive processes (e.g. speaking), and domains for which we likely do not have such evolved capacities (e.g. reading). Geary argues that learning of the former does not require instruction and can not be taught, while learning of the latter often does require or benefit from methods of direct instruction from experts.

***Cognitive Load Theory*.** The career work of John Sweller (2004, 2008) and colleagues (Sweller & Sweller 2006) has yielded the influential and empirically supported Cognitive Load Theory for instructional design. Sweller builds on the work of David Geary's biologically primary versus secondary learning distinction, yet takes evolutionary theorizing in a more generalized direction as well. By conceptualizing the cognitive architecture of the (human) mind as a *Natural Information Processing System*, Sweller argues that a partial analogy can be drawn to processes between genetic and cognitive evolution, and that this analogy is central to understanding the constraints and requirements of effective instruction.

***Self-Directed Education*.** Championed by evolutionary educational psychologist, Peter Gray (2011), Self-Directed Education employs an evolutionary theoretical narrative about the role of intrinsic human motivations to learn in mixed-age autonomy-supportive social environments to argue for a significant departure from the more rigid and hierarchical institutions of most modern schooling paradigms.

Self-Determination Theory. This theory of human motivation and psychological needs, developed by Deci & Ryan (2011), has been very influential in educational research towards the design of learning environments that maximise intrinsic motivation and well-being in students and teachers. Ryan & Hawley (2016) have contextualized the evolutionary origins and functions of the psychological needs of autonomy, competence, and relatedness in human motivation and well-being, as posited by Self-Determination Theory.

Prosocial Schools. Integrating generalized evolutionary theories with theories of collective action and psychological flexibility, Prosocial Schools is an organizational circle within Prosocial World (based on Atkins et al. 2019) which uses perspectives in cooperation science to synthesize educational innovations and network school improvement stakeholders. In this model, the eight *Core Design Principles* for cooperation originally identified by Elinor Ostrom and colleagues, and later generalized (Wilson et al. 2013), serve as a conceptual framework for the synthesis and design of participatory school improvement projects. We have previously discussed the complex relationship between the generalized conceptualization of evolution in Prosocial and the mainstream (gene-centric) conceptualization of evolution in general education (see Eirdosh & Hanisch 2020a).

Visible Learning. Educational researcher, John Hattie, has conducted the largest meta-analysis of educational efficacy research, organizing his insights into a synthesis he calls *Visible Learning*. Together with learning scientist, Gregory Yates (see Hattie & Yates 2013), Hattie has outlined a theoretical context for their synthesis of best practices, that is grounded in a socio-cognitive view of learning and evolution very congruent with, yet distinct from, the knowledge synthesis being advanced by Prosocial Schools.

Networked Improvement Communities. The influential school improvement strategy of *Networked Improvement Communities* (see Bryk et al. 2015) is broadly contextualized in evolutionary terms and has been developed on an explicitly generalized model of social learning as an evolutionary process, as conceptualized by learning theorist Douglas Engelbart (1962). In this model, collective human intelligence is seen as co-evolving with technology to support the kind of multilevel networked improvement communities that are at the heart of this school improvement model.

Each of these examples employs evolutionary concepts in sometimes similar, but often very different ways, conceptualized from different traditions across various disciplines. Many, if not all, of these theories *may* be argued to be congruent with each other along some dimensions, able to be integrated into a larger, more coherent generalized evolutionary theoretical framework. However, in practice, the theories above represent largely (though not entirely) disconnected education and research communities, with sometimes incongruent conclusions about educational design. For example, *Self-Directed Education* theorists and *Cognitive Load* theorists may have varyingly strong disagreements about the role of direct instruction and

structured curricula in modern schooling. Prosocial Schools is one notable outlier here, in that this community explicitly seeks knowledge synthesis across many of these diverse traditions. Overall, we see this broader fragmentation and potential discordance across evolutionary theories of schooling as an opportunity for scientific learning and development.

Towards a more generalized, integrative, pluralistic, and participatory approach

The fractionated state of evolutionary theory within school improvement literature suggests a possible opportunity in exploring how a more systematic approach to *coherent theory building* (see Hanisch & Eirdosh, this volume) may offer value to diverse education stakeholders. We suggest that such an approach should include at least four core design commitments:

Generalized

In line with educational design research (McKenney & Reeves 2018), a community science model for school improvement should be developed across *multiple levels of abstraction*, from highly *generalized principles* that apply across widely diverse contexts, to supports for *local theorizing* about adaptation in local contexts. This aids the potential *compatibility* and *tolerance* of the model to be applied with integrity across diverse school communities.

Further, we suggest that a community science model should be built around critical reflection on the generalizability of core evolutionary concepts and conceptual relationships. That is, rather than embracing one particular tradition in the expansive landscape of evolutionary theorizing described above, a community-based model can engage students and school community members in reflective analysis of the scientific or practical value of generalizing evolutionary concepts in specific contexts.

Integrative

Given the expansive scope of relevance of evolutionary theorizing in school improvement, approaches should be integrative, seeking to empower educators and students to “work smarter, not harder”, and “do more by doing less”. That is, evolutionary approaches to school improvement offer potential that spans academic learning, social-emotional development, and sustainable community development. For that reason, emphasis should be placed on the potential for pursuing multiple aims within interdisciplinary programs, rather than continuing to develop fragmented programs across these areas. This can be done intentionally within the context of addressing the critical challenge of *curriculum overload* (OECD 2020) in school improvement.

Pluralistic

This expansive scope also yields the greatest challenge in interdisciplinary evolution education: the diversity of expert and novice perspectives on the nature and value of evolutionary theory (and theorizing in general) in the improvement of schools or society. That is, many individuals

from many different backgrounds have many, often strong, opinions on what and how school improvement should look like, and if or how evolutionary concepts should be integrated in such efforts. For this reason, a community science model for school improvement must embrace a strategic pluralism (see Lohse, this volume). We specifically suggest a stronger emphasis on teaching about the *Nature of Concepts* as part of *Nature of Science* pedagogy. That is, the challenges of advancing a pluralism that is not relativistic (sensu Van Bouwel & Weber, 2008) requires deeper reflection on the nature of scientific explanations and the concepts we employ to construct such explanations. For that reason, engaging students in the critical analysis of the explanatory value of generalizing evolutionary concepts represents a novel pedagogical approach to navigating the conceptual diversity of the science.

Participatory
Finally, the novelty and complexity of advancing a community science model requires a deeply participatory approach to the design and spread of innovations (Atkins et al 2019; Mintrop 2018; Boyd 2014). Many schools embrace some degree or dimension of participation in school improvement, but this varies widely, and there remains little consensus or practical guidance regarding the conceptual learning dimensions of what students might need for, or gain from, engaging as participants in school improvement processes.

Developing a community science model

Schools can be understood as active drivers of cultural evolution, shaping mental models of the next generation towards selected societal aims. In the 21st century, these aims have increasingly shifted from the transmission of knowledge of facts, procedures, and basic literacy (though these are still important to achieve on a global level), to more integrated and progressive competencies such as interdisciplinary and critical thinking, systems thinking, cooperation, self-regulation, and ethical evaluation competencies, as illustrated by the range of 21st century competency frameworks that have been put forward (Griffin et al., 2012; OECD, 2019; UNESCO, 2017).

At the same time, schools and education systems are also challenged by the rapidly changing demands of the 21st century. These range from “curriculum overload” (OECD 2020) due to the ever increasing body of cultural knowledge that could be transmitted to the next generation in a finite amount of time, to the mental health issues of teachers and students such as burn-out, depression and anxiety that appear to stem from problems of how school culture and school climate are structured (e.g. Pelletier et al., 2002). Critically, these dynamics may be significantly interdependent, such as cases where curriculum overload may be implicated in teacher burn-out or retention.

Many frameworks and methods exist that aim to help schools in addressing these problems of practice - ranging from improvement of learning environments (e.g. Aldridge et al., 2012) and school climate (e.g. Thapa et al., 2013), enhancing teacher collaboration and collective efficacy

(e.g. Donohoo et al., 2020; Kelchtermans, 2006), fostering student voice and participation (e.g. Beattie, 2012; Bell & Aldridge, 2014; Halliday et al., 2019; Mitra, 2004; Ozer et al., 2020), and fostering student social-emotional learning (e.g. Clarke et al., 2015; Durlak et al., 2011; Seligman et al., 2009).

However, this diversity of existing approaches to school improvement usually co-exist in a more or less isolated fashion, or as competing alternatives for improvement and evaluation in which to invest limited school resources. Education researchers point out that educators are increasingly overwhelmed by these competing solutions and frameworks (Kivel, 2015; Mintrop, 2016).

Furthermore, existing approaches usually do not explicitly integrate teaching and learning *about the science* underlying the theory and methods or the processes of behavioral and cultural change that such efforts target, especially not in terms of integration into school curricula.

With this context in mind, we have been working since 2019 within our Community Science Lab at the Department of Comparative Cultural Psychology to develop some foundations for a community science model within the context of interdisciplinary evolution and school improvement sciences. The scale of the challenges and opportunities in engaging this work, both in terms of theory and practice, are significant. For this reason, humility, caution, and room for exploration have served as guiding principles in our efforts to clarify this potential. Our approach has included both exploratory innovation development and theoretical synthesis work. We have co-designed youth-driven sessions with a core team of four local secondary school students, in 10th grade as of this writing, and we have been working with them since the 2019-2020 school year, their 8th grade year. In parallel with this, we have worked to synthesize a range of core theoretical and methodological perspectives from a diversity of disciplines across evolutionary anthropology and school improvement sciences.

The sub-sections below outline the core theoretical and conceptual elements emerging from our work in developing this model, prior to summarizing the case study of our Evolving Schools project.

Schools as field sites for community-based cultural evolution

Biologists and social scientists, including cultural evolution researchers, have long conceptualized the regions they are interested in as *field sites* for scientific understanding. Often this research has been of a top-down nature, with researchers driving the questions and reaping much of the benefits, relative to local communities (see Urassa et al. 2021). Trends in community-based research (e.g. Boyd 2014) suggests the need and possibility to advance more equitable and more effective scientific research through a range of participatory methods. David Sloan Wilson (2011) notably used evolutionary theories to conceptualize his academic home city of Binghamton, New York as a field site for cultural evolution, including school-based

research collaborations (Wilson et al. 2011). Importantly, however, this approach lacked the conceptual learning integration we emphasize here, which we argue is central to an authentic commitment to community empowerment. In this context, we suggest that schools present a novel and important stakeholder context for advancing community-based methods in applied cultural evolution research, what we will refer to as *Community-Based Cultural Evolution (CBCE)*.

In contrast to a top-down view from external scientists onto the field site communities they study, CBCE suggests a more endogenous perspective. At every level of social organization (Fig. 1), individuals and groups, to varying degrees, can freely choose to think of themselves as an applied field site for understanding and improving valued outcomes. Additionally, members of such community-based field sites may variously choose to employ evolutionary concepts to advance their understanding of the cognitive, behavioral, and cultural change within their site. An approach or project can be said to be aligned with our concept of CBCE to the degree it is (1) endogenously and intentionally driven by stakeholders, (2) driven by the critical application of evolutionary concepts, and (3) engaged in iterative, cumulative, and participatory approaches to empirical understanding. These minimal criteria of course require further clarification and operationalization, however, here we will focus deeper on the implications of this model for school communities as related to aims in interdisciplinary evolution education.

Fig. 1. The Multilevel Field Site. From the individual to the planetary scale, members within these levels of organization can diversely conceptualize themselves as a field site for

understanding and improving valued outcomes. In the context of schools, students and teachers can be empowered as community scientists to understand and influence positive cultural change within their school, local, or global communities.

Schools are unique communities from this perspective, in that, school communities have the explicit aim, in one form or another, of cultivating cultural knowledge about the human condition and the nature of society while also cultivating a range of valued societal outcomes. Schools are communities in which the goals of conceptual understanding of cognitive, behavioral, and cultural change are deeply interdependent with the goals and experiences of change or stasis in these same domains of everyday life. Table 1, below, maps the differences that can emerge in a CBCE approach in which a school is focused on endogenous identity building around field site infrastructure and processes for improvement through conceptual understanding.

Table 1. *Differentiating field sites in applied cultural evolution versus Community-Based Field Sites in Community-Based Cultural Evolution.*

	Field site approaches to applied cultural evolution research	**Community-Based Field Sites / Community-Based Cultural Evolution**
Role of external researchers	External researchers *identify the community* as a field site	Community members *drive identity-building* around field site *infrastructure* and *processes* for improvement
	External researchers conduct research *on* or *with* local communities	External researchers support design-based research *for* community-based field site development
	External researchers own the data and control workflows (possibly with community co-ownership)	*Community members own the data* and control workflows (possibly with external data sharing agreements)
Research foci	Primary focus is on *intervention development* and *testing*	Primary focus is on *field site development* (i.e. tools and systems infrastructure for multilevel intervention development and testing)
	The *conceptual understanding* of participants is not necessarily accounted for or focused on within an intervention	The *conceptual understanding* of community members is a central aim of field site development
	Weak focus on *structures of knowledge* in science and community (i.e. the focus is on the *expert development* of cultural evolutionary theories to empower locally adaptive solutions)	Strong focus on *structures of knowledge* in science and community (i.e. the focus is on *distributed social networks* of coherent and pluralistic cultural evolutionary theory development; see Hanisch & Eirdosh, this volume)

For that reason, understanding this interdependence between what students learn about humans and how they engage school or society as a human, is a keystone conceptual space for advancing CBCE as a model for school improvement, and therefore, a strategic focal point for self-identified school field sites to advance community-based research.

The Metacognitive Loop

We humans vary significantly in our *conceptual understanding* of human nature and human capacities for valued change or persistence (i.e. that is, our understanding of the *adaptive flexibility* of human behavior, cognition, and culture). We also vary significantly in those *actual capacities* for adaptive flexibility as individuals or groups. How variations in these two domains influence each other is less than clear. We refer to the likely complex and reciprocal interdependence of these domains as the *Metacognitive Loop* (Fig 2). Metacognition, a concept developed in the educational research of Flavell (1979), has been adopted and adapted across various fields of the human sciences, with subtle and more overt differences in meaning. Here we adopt a highly generalized concept of metacognition as *cognition of or about cognition*. This includes even perhaps unconscious self-awareness of our performance in a task (sensu Heyes et al. 2020), as well as more abstract reasoning about other cognitive agents or systems (sensu Boyer 2018). In this context, the concept of metacognition can be applied both to conceptual understanding and adaptive flexibility. That is, the conceptual understanding of an individual or group about the diversity and flexibility of human behavior, cognition, and culture, represents a form of *metacognitive knowledge* that may or may not be drawn upon in the (potentially adaptive) decision making processes of the agent(s) in a given situation. For example, conceptualizations of self or society as fixed, rigid, or inflexible, may reinforce individual or group behaviors that are maladaptive in some contexts. In contrast, conceptualizations of self and society as complex, dynamic and potentially flexible systems, may support the emergence of more adaptive behaviors (see Wilson, D.S. 2011; Ciarrochi et al. 2016). Interestingly, this example points to a potential overlap between a scientific (complex systems) understanding of human behavior, and adaptive everyday conceptual understandings that students may or may not develop.

Fig. 2. The Metacognitive Loop. A generalized and idealized conceptual model for highlighting the poorly understood reciprocal relationships between our conceptual understanding of human behavior, cognition, and culture, and our adaptive flexibility in these same domains. The model is

intended particularly for the applied domain of general education curriculum design, to better engage questions regarding the role of *human experience concepts* in the curriculum.

It could be argued that the holy grail of general education is to create the conditions to reliably support humans in developing a conceptual understanding of the human condition that is both scientifically adequate *and* adaptive towards identified values across different levels of social organization. Curricula are currently overloaded with unstructured and fragmented knowledge that may not reliably support these aims. We suggest that a deepened emphasis on multi-pedagogical approaches for the understanding of *human experience concepts* (Stern et al. 2021), the concepts of human *behavior*, *cognition*, *culture*, and *systems* that pervade the everyday lives of students globally, may frame one core opportunity for educational innovation (see also Hanisch & Eirdosh 2020c). That is, giving students ample opportunities to engage the human condition as conceptual *content* for learning, as well as *context* for creative and critical social change, may drive adaptive cycles of development within the metacognitive loop, and therefore provides a uniquely integrative framing for school improvement efforts. Such a direction requires the elaboration and operationalization of constructs adequate to the task.

Theories of Self, Schooling, and Society

As discussed in Hanisch & Eirdosh (this volume), cognitive scientists have advanced a view of human development as one of testing and elaborating theories about the world (Gopnik et al. 1999). Infants notoriously test and develop intuitive theories about the physical world around them (Shtulman 2017). Young children go on to develop theories of their social world, developing *Theory of Mind (ToM;* Wellman 1992) about the knowledge, beliefs, and goals of others. Parents of children around the world have been said to have adopted variant *ethnotheories of parenting* (Harkness & Super 1992) which reflects and governs their knowledge, beliefs, and goals in relation to their children. And all of us develop deeply intuitive theories or mindsets about ourselves and the societies in which we live, theories that influence and govern our most everyday and life changing decisions (sensu Wilson, T. 2011).

In this tradition, we propose that all humans who develop in environments where schooling is present will likely develop more or less intuitive *ethnotheories of schooling*. Some humans make their *Theories of Schooling (ToS)* explicit and testable, sometimes through more or less formal scientific methodologies (sensu Mintrop 2018), others may evolve their ToS through other individual or cultural learning processes. The myriad possible relationships between folk and expert ToS are not well understood, but likely significant for the design of adaptive learning environments. This chapter can not begin to fully explore the conceptual space suggested by ToS, but aims only to contextualize the concept within the broader CBCE model.

Specifically, we agree with Barrett (this volume) that, when thinking about folk ontologies, we should not apriori project or assume that such ethnotheories will fall within the same disciplinary structures as western academia (i.e. folk physics, biology, psychology, see Shtulman

2017). Instead, we offer a proposed structure of knowledge for understanding ToS (Fig. 3) that is specifically designed to support applications in curriculum design and school improvement.

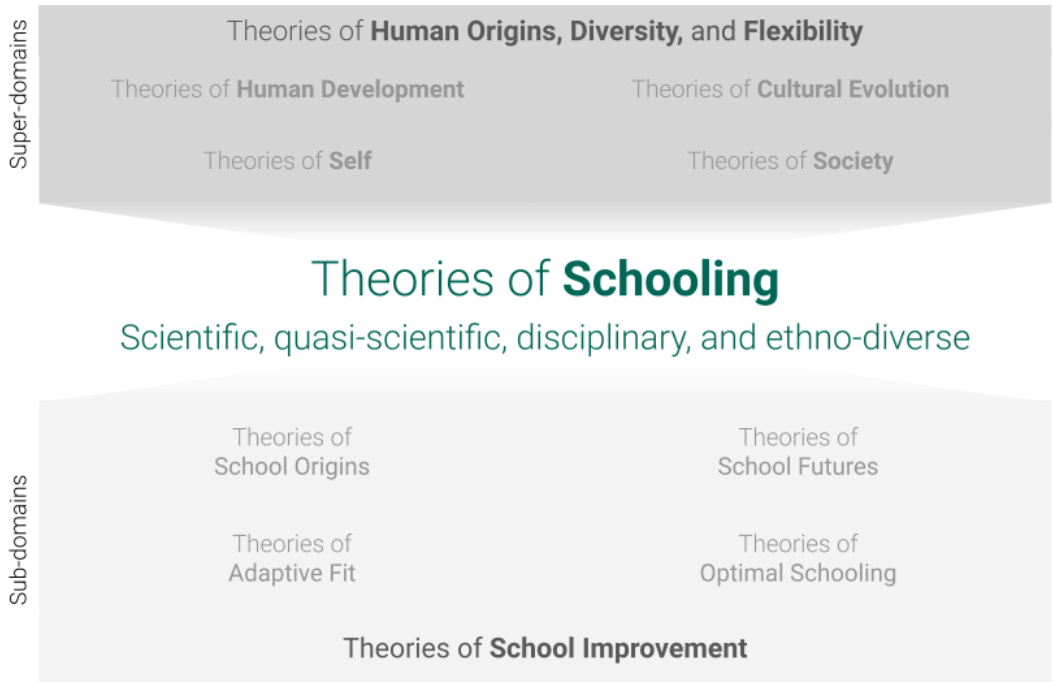

Fig 3. A proposed structure of knowledge for the comparative study of scientific, quasi-scientific, disciplinary, and ethno-diverse Theories of Schooling.

By understanding this structure of knowledge, curriculum designers interested in supporting informed participation of stakeholders in school improvement processes may begin to think about the deeper conceptual structures of the curriculum in relation to the development of scientifically informed and adaptive local theories of schooling. That is, what kinds of knowledge and transferable understandings do students have or need to adequately reason about the development of their own school? Stakeholder participation is about engagement of 'non-experts' or 'local-experts', and yet, the unique pedagogical aims of school communities might suggest we can look again at how best to scaffold student understandings (of themselves, schools, and society) that are adaptive for the world as we find or make it. That is, within a CBCE approach, we can seek to better understand, predict, and influence the (cognitive, behavioral, and cultural) evolution of adaptive theories of schooling across whole school communities (inline with Atkins et al. 2019).

A short-form model of this approach could be through an activity that allows students to make explicit their own theories of schooling in relation to a specific scientifically informed theory. We summarize exploratory lesson models from our Evolving Schools project in the next section, however, this exploratory work lacks integration within broader local school improvement processes, and thus falls short of our vision for a CBCE approach.

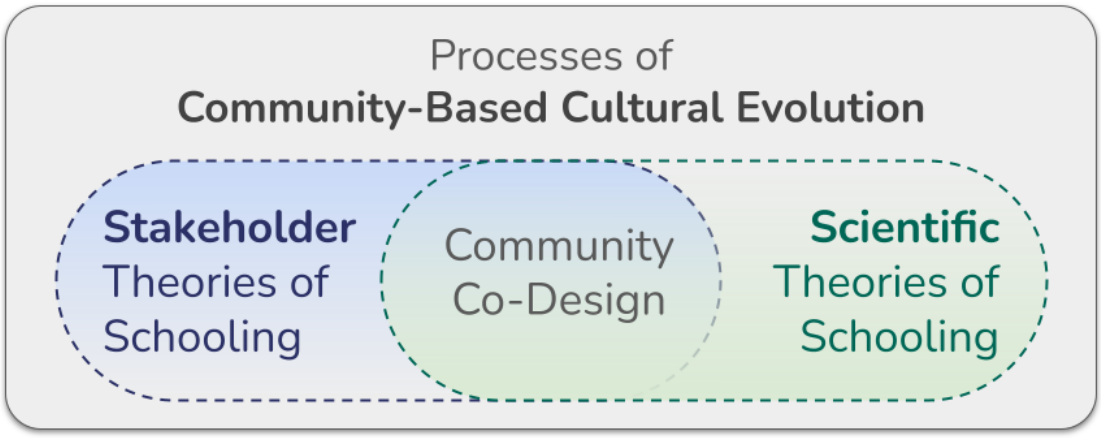

Fig 4. Processes of Community-Based Cultural Evolution. The critical reflection of stakeholder ToS against diverse scientific ToS, can be one driver of community co-design of school improvement strategies. When these strategies then drive conceptual understanding and adaptive flexibility within and between individuals and school communities, processes of CBCE can be said to be occurring.

A long-form model of CBCE would require a more systemic, interdisciplinary, and whole-curriculum approach. We suggest processes of *CBCE* can be said to be occurring within a school community when processes emerge that drive reflection between stakeholder and scientific theories of school improvement, in ways that can drive actual community co-design of on-going school improvement efforts (Fig.4).

Achieving this vision requires a more elaborated *theory of improvement* to support school improvement stakeholders in advancing this work locally.

Our Theory of School Improvement

First through our educational design work in the Global ESD project (www.GlobalESD.org), and now through OpenEvo (http://openevo.eva.mpg.de), we continue to refine our *Theory of Improvement* (Fig 5) derived from the concepts above. Critically, this is a minimal and generalized conceptual model of school improvement based on the aim of curriculum-scale

coherence (see Hanisch & Eirdosh this volume).

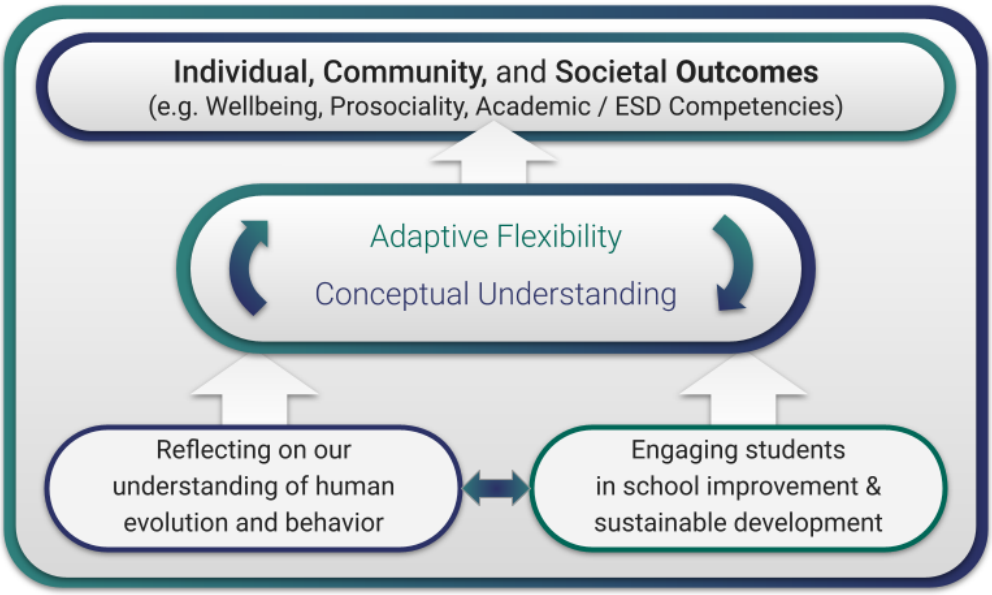

Fig 5. The OpenEvo Theory of School Improvement. A minimal and generalized model for organizing educational design research across grade levels, subject areas, and other aims or structures of the general education curriculum.

The (very general) constructs and normative goals have been synthesized from evidence-based and widely accepted aims within global education discourse (see Hanisch & Eirdosh 2020c). The model emphasizes the complex, interdependent, non-linear, contextual, and reciprocal relationships between conceptual understanding and adaptive behavior (the *Metacognitive Loop*, above). Importantly, the model is not explicit about which specific conceptual understandings or which specific processes of adaptive flexibility are normatively optimal in a given context. Rather, the model focuses on engaging stakeholders in noticing if their current mental models, behaviors, or cultural institutions are adaptive in relation to their locally identified values, and maintaining or altering this variation as valued (sensu Atkins et al. 2019; Ciarrochi et al. 2016). This is a process which we suggest can be optimized through two broad, interdependent classes of curriculum and lesson scale targets of educational design, one more conceptual, one more contextual or experiential.

One class of intervention focuses on helping students reflect on their understanding of human evolution and behavior. This is the dimension of the model more focused on conceptual learning, yet also benefits from integrating diverse pedagogical approaches. To this end, we have advanced our *Educational Design Lab* model that develops tools and opportunities for students and educators to co-design interdisciplinary science and humanities teaching resources focused on understanding *human experience concepts*.

The other class of intervention focuses on engaging students in school improvement and sustainable development processes. This is the more experiential and contextual dimension, yet also requires deep conceptual learning. To this end, we have advanced our *Community Science Lab* model that develops tools and opportunities for students and educators to co-design community science projects that seek to understand and influence the cognitive, behavioral, and cultural variation of their school community.

Critically, both classes of intervention would theoretically be strengthened if a conceptually coherent framework for understanding human behavior, cognition, and culture can be structured (see Hanisch & Eirdosh, this volume). Such a structure is beyond the scope of this chapter, but we can provide a summary case study for exploring elements of our broader *Theory of Improvement* within our *Evolving Schools* project.

Case study: The Evolving Schools project

The core concepts for a CBCE approach outlined above developed through interdisciplinary knowledge synthesis and exploratory work within our student-centered Community Science Lab in Leipzig, Germany. Previous work (Eirdosh & Hanisch 2021) has documented the origins and early stages of the lab's *Evolving Schools* project, on which we will build to add context within the CBCE approach.

The Evolving Schools project started in March 2020 and has continued to develop through the present. The central guiding question for the project is:

How can students and school communities engage scientific perspectives on human behavior, cognition, and culture as a foundation for the participatory improvement of their own school?

Exploratory educational design work has led to a range of pilot projects engaging students in grades 7-12 in conceptual learning and critical reflection on evolutionary theories of teaching, learning, and schooling. The starting point for this work is often to elicit student conceptions, gaining a better understanding of how students' prior knowledge may inform their reasoning about a given topic. In this case, we want to develop methods for exploring the full potential landscape of ToS among students in general education contexts. Towards supporting research in this space, we have developed and begun to pilot a range of tools (Table 2) that enable the explication and documentation of some dimensions identified within the structure of knowledge outlined in Fig 3.

Table 2. Evolving Schools toolkit for understanding local ToS

Theories of Schooling Sub-Domains	***Evolving Schools* project toolkit examples**
Theories of **school origins**	Survey and classroom discussions on: ● Timelines for origins of schooling and teaching? ● Why was the first school created? ● Do other organisms engage in teaching like humans do?
Theories of **adaptive fit** between schools and students	Survey and classroom discussion tools on the *workability* of current school design elements
Theories of **optimal schooling** & **school improvement**	Student interview and focus group protocols on the adaptive value potential and scientific legitimacy of evolution-informed Self-Directed Education models of schooling

These tools have been developed, piloted, and adapted for a range of grade levels and school contexts, often through real-world teaching, rather than formal research contexts. For this reason, we continue to develop the tool kit, while allowing access to any teachers or researchers interested in advancing this work further.

One tool within this project that has evolved the furthest towards a formal community science protocol is the interview protocol on Self-Directed Education. In this paradigm, upper grade students interview their peers and other school stakeholders around their perceptions of “a school where students make the rules”. Using various design elements from the evolution-informed *Self-Directed Education* model of schooling (see Gray 2011), student interviewers explain to participants a range of egalitarian and autonomy-supportive design elements of this school model, explaining that scientists continue to debate whether this school is a good model for *all* humans on the basis of our evolutionary history or simply “what is best for humans”. Interviewers then probe the participants' knowledge, attitudes, and beliefs about this model and perceptions on the scientific debate.

The aim here is not to present a synthesis of the findings from across the variant student projects that have employed this paradigm (through interviews, focus groups, and classroom discussions across grades 4-12, as well as parents, pre-service teachers, and educators), as variations in methods and consent, as well as limited sampling, prevent such a formal synthesis. Instead, we have summarized emergent thinking about common patterns in the everyday ethnotheories of schooling that we have thus far been able to theoretically predict and routinely find among stakeholders in our largely urban and European (i.e. WEIRD) school communities (Table 3). These selected example patterns of everyday ethnotheories relate to clear pedagogical opportunities within our broader educational design concept (sensu Hanisch &

Eirdosh 2020c), and thus represent early *educational design theories* (to be elaborated, operationalized, and optimized in local contexts) for the Evolving Schools project.

Table 3. Patterns and pedagogical opportunities in everyday ethnotheories of schooling.

Theories of Schooling Sub-Domains	**Patterns in everyday ethnotheories of schooling**	**Pedagogical opportunities**
Theories of **school origins**	Teaching and schooling evolved as a cultural adaptation to, and driver of, societal complexity (sensu Geary 2005).	Use to develop and strengthen interdisciplinary evolutionary reasoning through critical questions about the complex causal dynamics of social learning, cooperation, and complexity across living and human systems. (see Hanisch & Eirdosh 2020b).
	Misconception: teaching is common across the animal kingdom (contra Kline 2015).	Use to clarify the concept of teaching as active behavior intended to promote adaptive learning of others.
Theories of **adaptive fit** between schools and students	Individual dispositions and social context mark the end of a search for explanation. Phylogenetic or otherwise evolutionary explanations are rare (sensu Böhm & Pfister 2015; Hanisch & Eirdosh 2021).	Use to prompt critical exploration of theories and methods through which we can evolve our everyday theories towards great precision, scope, and depth (see Hanisch & Eirdosh, this volume).
Theories of **optimal schooling** & **school improvement**	*Minimal structure* for maximal *autonomy support* (sensu *Self-Determination Theory;* Deci & Ryan 2011).	Use as a conversation starter about community beliefs regarding the adaptive value of the current school community's curriculum structure and autonomy supports. Use as an example for understanding levels of abstraction and generalization in local ToS and scientific theories more generally.
	Emphasis on changes in topics of education rather than structures of knowledge (in contrast with Stern et al 2021; Hanisch & Eirdosh, this volume).	Requires classroom and curricular emphasis on creating a culture of conceptual thinking and transfer of learning. (sensu Stern et al 2021)

This early exploratory educational design work suggests that teaching and learning about the evolution of teaching and learning can be practically engaged within the general education curriculum, though much work remains to optimize and contextualize such activities locally. In this way, the integration and institutionalization of processes to help evolve adaptive ToS across stakeholders within formal school improvement processes should be a guiding aim in future developments.

This approach and the space of likely findings from such conceptual explorations do not lend themselves directly to short, simple, or single interventions, but perhaps point towards an opportunity for more interdisciplinary and integrative thinking about how students of all ages develop a conceptual understanding of human origins, diversity, and flexibility, as it relates to their everyday experience within their school community. The role of generalized evolutionary concepts in this understanding will depend on how students and curriculum designers more broadly understand the structures of knowledge in science and cognition. This in turn relates to how scientists within and outside of evolutionary theorizing understand such structures of knowledge. We suggest that the conceptually minimalist claims of generalizing evolutionary concepts (rather than “Darwinism” or “a Darwinian worldview”) provides a productive and coherent conceptual structure for helping students reflect on the nature of evolutionary concepts in educational contexts (see discussion in Hanisch & Eirdosh, this volume). That is, students can be better supported in understanding the complex causes (i.e. the variation producing processes and frequency changing processes) of their own evolving theories of schooling, in relation to the school they are a part of. Part of that support can include explicit explorations into the nature of evolutionary explanations across disciplines as part of broader Nature of Science learning goals.

Our Community Science Lab is now working to create a model open science workflow and digital research infrastructure to support secondary school students and school improvement stakeholders in working towards a truly global, open, community science project within the framework of Evolving Schools. Our hope is that this can be a complementary model for school communities to explore as they collectively evolve the content and context of their local curriculum.

Conclusions

In education, theory and practice are notoriously uncomfortable cousins in the family of school improvement practices. We need both of them at the table, but not everyone agrees about who should be running the reunion. Against that background, the conceptual complexities and clear lack of consensus on the generalizability of (or value of generalizing) evolutionary concepts, would seem to make interdisciplinary evolution a poor candidate for framing school improvement. Our suggestion, however, is relatively humble. Cognitive, behavioral, and cultural variation pervades the everyday lives of every human on earth. Schools are places for students

to advance a conceptual understanding of that variation as well as the skills to adaptively influence the variation in their own lives and in their communities. Helping students to more explicitly reflect on their own conceptual models of this change in relation to the generalizability of evolutionary concepts provides a novel strategy for interdisciplinary science education and participatory school improvement research. In this context, any school in the world can self-identify as a field site for driving their own CBCE processes through local community science and interdisciplinary evolution education projects.

Our framing of CBCE as focused on the endogenous self-identification of a school as a field site is meant to frame a more explicit commitment of external research partners as having a limited but still direct role in creating the autonomy-supportive conditions for local communities to be (or become) effective agents of local (or global) change. Additionally, external research partners are central nodes in strengthening theoretical coherence and global knowledge exchanges across globally diverse school field sites. This means that there is a role for applied educational design researchers to support partner school communities with resources, processes, and infrastructure for more effectively driving CBCE processes. This also means there is a role of scientists from across all disciplines working to apply generalized evolutionary concepts, to better engage the international evolution education community towards supporting interdisciplinary evolution education resources that can drive the conceptual learning theorized to complement the broader school improvement aims of CBCE processes.

The conceptual landscape of CBCE represents a vast expanse of opportunities requiring further development. We invite all school stakeholders, students, teachers, parents, administrators, community members, and researchers across disciplines, to consider how you can support the emergence of a community-based field site within your local school or school system.

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