WHAT DOES IT TAKE TO BE A FOX? NEW HORIZONS FOR MATHEMATICS COMMUNITIES OF PRACTICE

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In this theoretical research report we reflect on the challenges of becoming more fox-like in mathematics education work. Using a communities of practice motivating theoretical lens, we compare and discuss the differences in defining, creating, and accessing knowledge between virtual and scholarly communities of practice in mathematics education. We present four claims that virtual communities of practice in mathematics education are inherently foxy work. As part of our claims, we discuss how scholarly communities of practices are inherently hedgehog work. We conclude with a list of recommendations of those within the scholarly communities of practice in mathematics education. These recommendations include looking toward the successful fox-like attributes of the virtual communities in mathematics education.

Keywords: Instructional Leadership; Systemic Change

Drawing on Berlin's (1953) essay, *The Hedgehog and the Fox*, Boaler, Selling, and Sun (2013), ask the question to the mathematics education field: "Where are the Foxes in Mathematics Education?" Berlin uses the metaphor of hedgehogs and foxes for illustrating two types of thinkers and writers: hedgehogs as those focused on a singular idea and foxes as those who draw across ideas and make changes. Boaler and colleagues challenge those in the academy to be more "foxy" in their collaborations and research with intentional outreach to other communities. They note "although the production of research ideas is extremely worthy, if research ideas in mathematics education do not get taken up and used, by teachers, parents, and other educators, then their worth diminishes significantly" (p. 191).

In this theoretical paper, we explore questions around this challenge including: What does it mean to be a fox in mathematics education? To what degree does the field support members in becoming foxes? How might foxes within mathematics education use online communities in their work? Moreover, we consider how newly formed virtual communities in mathematics education might serve as new horizons for traditional scholarly communities.

An Array and a Skulk

Berlin's (1953) essay developed the conceit of the hedgehog and the fox as a lens for assessing the life and work of Leo Tolstoy. What endures from the essay is the idea that there are hedgehog-like thinkers and writers and fox-like thinkers and writers. Kilpatrick (2013) captures the difference between the two as a matter of scale and humility: the hedgehog knows all there is to know about one big idea, uses this information to understand the world in its entirety, and fails to recognize that there aspects of the world that cannot be known or explained. The fox, on the other hand, knows just enough about many things and also knows that some things are unknowable. Berlin (1953), Kilpatrick (2013), and Boaler and colleagues (2013) use the hedgehog/fox dichotomy for describing individual or cooperative activities (e.g., the work of Tolstoy, specific mathematics education research projects). Our interest in discussing this distinction is not for focus on individual hedgehogs or foxes, but rather to consider *collections* of

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each and the collective behavior of these different groups. Moreover, we use the hedgehog/fox distinction as lens for examining the kinds of activities that take place by different collections of math educators: the arrays of hedgehogs in academia and the skulks of foxes in what we describe below as the network of virtual mathematics education communities of practice and scholarly mathematics education communities of practice.

Motivating Theoretical Lens: Communities of Practice

Our motivating theoretical lens is formed from perspectives of communities of practice (Lave & Wenger, 1991). We apply this lens to virtual mathematics education communities of practice (vMEC) and also scholarly mathematics education communities of practice (sMEC). Although we make the distinction of these two different types of communities, virtual and scholarly, we recognize that some members of the sMEC are also engaged participants in the vMEC. Because the overlap between vMEC and sMEC is so limited, we treat these communities as distinct in our subsequent discussion and claims. These communities, the vMEC and sMEC, each have the three essential characteristics discussed by Wenger-Trayner and Wenger Trayner (2015): (1) a shared domain; (2) an engaged community of participants; and (3) a focus on practice (see, e.g., Hertel, Wessman-Enzinger, and Dimmel, in press, for further discussion on virtual mathematics education communities of practice).

Virtual Mathematics Education Communities

As social media platforms (e.g., Facebook, Instagram, Twitter) have become integral to people's daily lives over the last decade, virtual communities have flourished. We draw a distinction between platforms (websites that facilitate interactions among users) and the multitude of virtual communities that reside on such platforms. Moreover, although we are focused on virtual communities, the interaction between virtual and physical communities is complex (Ellis, Oldridge, & Vasconcelos, 2004). As Ellis, Oldridge, and Vasconcelos (2004) note, virtual communities have different features than traditional social networks:

Virtual communities are both narrow and specialized, in terms of the information posted, but at the same time broadly social and supportive. Consistent evidence suggests that many individuals go to virtual communities because of these social and supportive characteristics: the many weak ties supported by virtual communities provide access to a much wider network of people than conventional, social networks. The potential for invisibility regarding normal social cues such as gender, race, class, and age opens up the potential for networking and interaction that may be inhibited elsewhere. (p. 148)

We conceptualize these virtual communities as types of *communities of practice* (Lave & Wenger, 1991; Wenger, 1998; Wenger-Trayner & Wenger-Trayner, 2015) acknowledging that there are inherent differences between physical and virtual communities of practice. Moreover, within this theoretical paper we concentrate on vMECs that are focused on the teaching and learning of mathematics.

The shared domain of a virtual community of practice is independent of platform. Members of a particular vMEC might use several platforms concurrently (e.g., Pinterest, Facebook) or a single platform might host multiple vMECs. The shared domain of any particular vMEC is visible through the shared focus on teaching and learning of mathematics in the discussions, interactions, resources, etc. Additionally, smaller communities of practice each having a narrow focus may also be part of a larger vMEC (e.g., mathematics content at the elementary level, the professional development of mathematics teachers). Collectively vMECs make up a group that is

different from other virtual communities of practice and, at the same, time they form smaller communities that are distinct from one another.

The individuals who constitute a vMEC share information and help each other. Through this interaction, members build relationships, collaborate, support one another, and engage in the shared domain. The methods and kinds of engagement are influenced by the structure of the platform on which the vMEC resides. Some platforms provide robust tools for interaction and knowledge building (e.g., Mathematics Stack Exchange) while others provide limited tools for structuring interaction. The presence or lack of tools influences that degree to which community members can shape discourse.

Practice is always social (Wenger, 1998) and involves performing an activity within a social as well as historical context. Practice includes:

> What is said and what is left unsaid; what is represented and what is assumed. It includes the language, tools, documents, images, symbols, well-defined roles, specified criteria, codified procedures, regulations, and contracts that various practices make explicit for a variety of purposes. But it also includes all the implicit relations, tacit conventions, subtle cues, untold rules of thumb, recognizable intuitions, specific perceptions, well-tuned sensitivities, embodied understandings, underlying assumptions, and shared worldviews. Most of these may never be articulated, yet they are unmistakable signs of membership in communities of practice and are crucial to the success of their enterprises. (Wenger, 1998, p. 47)

The explicit and visible practices of an vMEC may be quickly recognized and adopted by a newcomer. The implicit, untold, underlying assumptions, on the other hand, may go unnoticed. Moreover, the space in which a vMEC resides can also create room for miscommunication since, unlike physical communities, participating in a vMEC typically requires no more than visiting a publicly viewable website or registering a free account on a platform. Consequently, although newcomers can easily participate in a vMEC, they may do so without understanding the practices of the community and the assumed knowledge base.

Scholarly Mathematics Education Communities

The shared domain of sMECs is ultimately the academy. Although participants of the sMEC belong to different communities themselves, all participatns of the sMEC have an affiliation with a university in some capacity. The engaged participants are often graduate students, researchers, research assistants, tenured professors, or untenured professors. Becoming an engaged participant within the sMEC requires a vetting—this usually entails participation in thesis or dissertation work at some point (e.g., Golde & Walker, 2006; Reys, 2000). The expectations in the sMEC for vetting through theses and dissertations mimic research processes described in common mathematics education journals (e.g., Williams & Leatham, 2017) and conferences, such as the Psychology of Mathematics Education-North America (PME-NA). Although some members of the sMEC are participants of the vMECs, the two groups operate largely independently with participants of the sMEC knowing little about vMEC active members of the vMEC (e.g., classroom teachers, math coaches, consultants) outside of the sMEC.

Claims

We now discuss claims that we believe are critical issues in the discussion of hedgehogs and foxes within the field of mathematics education. As noted, our focus with these claims is on general behavior of collections of foxes and hedgehogs. This shift to focusing on collections rather than individuals allows for consideration of how sMEC and vMEC support different kinds

of engagement with issues of teaching and learning in mathematics. We see these four claims as supporting the following position:

> The field is currently focused on generating hedgehogs (Claim 1) for work within sMECs and work within hedgehog systems. As a result, few within sMECs are positioned to obtain fox status (Claim 4). In contrast, vMECs offer a vision of mathematics education communities where there is more access and opportunity for becoming a fox (Claims 2 & 3).

Claim 1: The Scholarly Mathematics Education Communities are Designed to Produce Hedgehogs.

The very act of working on or obtaining a terminal degree (PhD, EdD, etc.) in mathematics education or a related field is a hedgehog idea. The academic journey members of sMEC undergo in graduate work is that of a hedgehog with narrow focus around developing robust knowledge of the field (pedagogy, research, etc.) before posing and researching a circumscribed, theoretically framed question whose investigation contributes to this knowledge base. This work is disseminated in hedgehog ways through a dissertation and (sometimes closed) defense. The structure of the dissertation itself is a hedgehog production built upon accepted norms of academic discourse—hundreds pages filled with complex, academic jargon that only insiders in that area read.

After graduate school, those in the field seek positions in the academy. Many in the sMEC obtain tenure-track positions at universities, which are built upon hedgehog systems. For example, tenure, whether at a teaching college or research university, is achieved through a combination of demonstrated proficiency in teaching, scholarship, and service. Related to scholarship, peer-reviewed publications are highly valued. Although some publications may be written for a more general audience, most are focused more narrowly on a subset of the sMEC community. Moreover, the articles themselves are produced to adhere to the norms of academic discourse and written for members of the sMEC community, rather the mathematics education community at large.

Claim 2: Hedgehogs Can Flourish in a Closed System; Foxes Require Access to Flourish.

Members of the sMEC are inherently part of systems where production of knowledge is more important than the access to knowledge. These mathematics education hedgehogs produce knowledge through research that is focused in a particular domain in the field (e.g., children's thinking about operations with fractions, student positioning in number talks). Likewise, the systems in which graduate students are trained to work (i.e., higher education) value the production of knowledge and the systems in which we work require the production of knowledge (e.g., dissertations, publications). This knowledge is disseminated through peer-reviewed articles, conference presentations, or other publications. Most of these publication venues are creations of the sMEC community itself although some may be owned by other entities. As such, these venues are maintained by members of the sMEC and access to them challenging for those in the vMEC who lack institutional financial supports. Likewise, an individual who is trained as a hedgehog, but resides outside of the academic structure, will struggle to access most of the newly created knowledge.

The monetization of knowledge generated by members of the sMEC showcases how access to knowledge is less important than the production of knowledge. This monetization occurs in various ways even beyond the required memberships to organizations or journals stated above. Only a few of the sMEC organizations have open access to the knowledge they curate or promote the freely sharing of knowledge to those outside the community. In fact, open access is

not given a particular value by the field or the sMEC as a whole, which can lead to inconsistent policies within groups. For example, although the proceedings for PME-NA are freely available online, the proceedings of the larger parent organization, the International Group for the Psychology of Mathematics Education, are not free to download. Some scholars seeking to work around the prohibitive structures of academic publication make prepublication versions of their work (papers, book chapters, etc.) available for download. Although this shows the desire of many authors to work around the access-limiting structures, it is also evidence of the degree to which the field ignores the importance and challenge of access.

The very nature of the expectations in the academy, or the sMEC, limits what those in the academy consider transformational. Reaching out in transformational work beyond the research required for typical peer-reviewed journals is an afterthought or an "if we have time" mantra. Time constraints notwithstanding, there is also the risk, when reaching out to the general public, that one's scholarly work will become popular, at which time one's academic reputation may be impugned for doing unserious work. Or, one may spend time working with the general public and lose credibility within the academy for doing unscholarly work. This is evidenced by the academy's emphasis on scholarly production and de-emphasis on service.

Conversely, within vMECs the sharing of knowledge and the creation of knowledge are equally important. Reaching out to those beyond a niche community is the purpose of any post or work; this starkly contrasts many situations within sMEC. Even if those with large-scale funding (e.g., NSF) engage in transformational work, the access to this work is often lacking. This presents hedgehog findings making their way into thousands of teachers' classrooms in the same ways available from MEC. Likewise, although an individual in sMEC may spend years studying children's thinking about integer addition and subtraction deeply, sharing this work in an open and accessible way if the individual wishes to have an impact within the vMEC.

Members of the vMEC need to make sense of student's thinking about many domains of mathematical content and also the accompanying pedagogical work that leverages this thinking forward. Members of the vMEC come together and use social media platforms as a ways to share knowledge about making transformative work in mathematics education. Simply put, those in the vMEC are trained mathematics practitioners and inherently engage in foxy work (e.g., instructional coaches for a range of grades, teachers who teach many different topics). Despite the varying roles of vMEC (e.g., math coaches, teachers, math consultants), there is a common goal of connecting larger mathematical ideas and transforming education for students. Although those in the sMEC may value transformational education for students, the field is submerged in a hedgehog system that perpetuates closed structures (e.g., publications in peer-review journals, tenure).

Claim 3: The vMEC Presents Opportunities for Developing Foxes More than sMEC.

The vMECs have more opportunities for developing foxes than the sMECs. Moreover, we claim that vMECs are inherently foxy communities of practice. In the shared virtual spaces of the vMECs (e.g., Twitter chats like #mathchat, Facebook groups), the engaged participants wish to evoke change. This constitutes sharing things in public, free, open-source ways. Because the work is inherently foxy, there are more opportunities for the members of the vMEC to flourish when compared to those within the sMEC. Participants in the sMEC have less opportunities to engage in discussion of knowledge and shared knowledge. Most participants in the sMEC discuss their work through conferences or journal articles. Although they may get to speak with members of the sMEC about their work at a conference, the members of the sMEC have limited opportunity to discuss their work published in articles beyond receiving feedback from reviewers

and editors. Members of the sMEC rarely know if their work is being taken up or are able to share it freely. Conversely, the very nature of knowledge expectations of the vMEC requires interactions with others publicly and freely shared.

There is clear evidence of the influence these communities have had on mathematics education. An example of the inherent foxy work of vMEC are 3-Act Tasks. 3-Act Tasks are mathematical cultural phenomenon that constitutes an ideal example of highlighting transformative, foxy work part of the vMEC. A 3-Act Task is a task presented as a way of mathematical storytelling in three specific parts or acts (e.g., http://blog.mrmeyer.com/2011/the-three-acts-of-a-mathematical-story/). In the first act, the story is visually told. This act entails beginning with a video of a contextual situation, like picking up eggs out of a cartoon or packing meatballs in a pot of water. The videos do not contain words, symbols, or questions. It is essential the videos are visual with a change happening and open-ended. The second act, the protagonist/student/learner has a need for overcoming an obstacle. This may entail mathematizing the situation, looking for resources, or creating tools. For example, in a video where the protagonist is packing meatballs in a pot of water, one may wonder how many meatballs can be packed without overflowing the water in the pot. Learners may mathematize this situation by starting to unpack ideas of volume and displacement. In the last act, act three, there is resolution to the story and conflict. This is the space where mathematical problem solving occurs. Due to the open nature of the video and conflict, it is likely that there are multiple strategies, solutions, and robust discussion about the conflict resolution.

Countless teachers and other practitioners know what a 3-Act Task is and use them routinely. Although 3-Act Tasks have recently found themselves in traditional, scholarly peer-review spaces (e.g., Lomax, Alfonzo, Dietz, Kleyman, & Kazemi, 2017), the inaugural roots of 3-Act Tasks began on a blog by Dan Meyer. Through the Mathematics-Twitter-Blogosphere (MTBoS) and vMECs, numerous educators began using 3-Act Tasks. Graham Fletcher categorized a vast array of 3-Act Tasks for elementary school; these tasks with videos are freely available (e.g., https://gfletchy.com/3-act-lessons/). Using the hashtag #3ActMath on Twitter platform reveals quick insight into the power of the MEC in these the virtual communities and transformational impact on mathematics pedagogy. In a way, the 3-Act Tasks have been "researched" by the engaged participants in the shared domains of the MEC. There are many examples of this within the vMEC. In fact, all of the examples in the vMEC are fox-like work. Yet, very little of the work in the vMEC is picked up or used within the sMEC.

Claim 4: Few Within the sMEC Are Positioned to Be a Fox Whereas Anyone Within the vMEC Has Potential to Become a Fox.

Our final claim is that only a handful of individuals within the sMEC are positioned to become foxes. This is because the path to becoming a fox from within the sMEC requires first demonstrating one's competence and ability as a hedgehog. The practices and norms of the sMEC create narrow avenues for becoming a fox. For example, some members become foxes through their successes as hedgehogs (e.g., articles, books, grants). Others attain fox status through their work as leaders within professional organizations. The sMEC celebrates and rewards the achievements of hedgehogs through a variety of structures including awards, honors, and guest lectures. Foxy work that lies outside of typical hedgehog activities is not valued in the same way. For example, non-peer reviewed work (e.g., blog posts, Youtube Channel) that is open to the public is not seen in the same light as scholarly publications.

In contrast, foxes in the vMEC are typically individuals who exist outside of the traditional academy. These bloggers, writers, and teachers have built their credentials upon popularity.

Moreover, the popularity itself is made possible by open access to the created content and serves as a proxy for an individual's position within the vMEC. Thus, becoming a fox within the vMEC relies upon the actions of the individual rather than their position within a system.

One's position as a fox within either the sMEC or vMEC determines the amount of influence one is able to yield. Members of sMEC, for example, may listen to those who have earned prominence in a plenary speech with assurance that the structure of the academy has guaranteed the speaker's qualifications as a hedgehog. In contrast, within vMEC prominence is earned through popularity of content. As such, prominent foxes are those whose content creations have become well known. Furthermore, whereas foxes with the sMEC largely have doctorates, a long list of publications, and a history of groundbreaking research, those prominent in the vMEC, in contrast, do not necessarily have they characteristics. What vMEC foxes do have, however, are curated free, open-source content that is connected to many mathematical topics.

Encouraging a Skulk of Foxes from Within Academia

As others have identified (Boaler, Selling, & Sun, 2013; Kilpatrick, 2013) there is a need for more foxes within the sMEC. But what are the attributes of being a fox? How can those outside of privileged positions (e.g., tenure, prominence in field) do foxy work? As we argue above, the field is currently focused on generating hedgehogs (Claim 1) to work within a system that is closed to most of the outside world (Claim 2). This structure limits opportunities to become a fox (Claim 3) and positions few within sMEC to obtain fox status (Claim 4).

Calls for more foxes in mathematics education are important, but what we need are more *skulks of foxes*—groups of foxes—in mathematics education. This is not an individualistic endeavor; it is a group or systemic change that must take place. We believe that the field must begin to address some of the structural barriers toward becoming a fox. Most importantly, the limited access to content needs be addressed so that innovations within research and teaching from within sMEC can have a broader influence with vMEC. This is more than a call for increased open access journal articles. Rather, it is a call for structural changes and community expectations so that those in the sMEC can engage in work that integrates both the scholarly rigor our field requires alongside the outreach needed to reach the practitioners who reside outside the closed system.

Those within the sMEC have made initial steps toward structural changes and issues of access. For example, the journals *Teaching Children Mathematics*, *Mathematics Teaching in the Middle School*, and the *Mathematics Teacher* have monthly free-preview articles with accompanying Twitter chats. The *Mathematics Teacher Educator* (MTE) journal also started a podcast that is open access about select articles in the journal.

This is challenging work that needs to be done by the sMEC community—individuals alone cannot make systemic changes. Those in the sMEC need to think about collective ways they make changes to *access* of knowledge—particularly since views on creations of knowledge cannot be changed (e.g., dissertations, research). We challenge readers who belong in the sMEC to reflect and take-up the following questions:

How can we focus on access within the field?
How can we change those journals within the control of the sMEC (e.g., Journal for Research in Mathematics Education, MTE) to focus on open access?
How can we open up meetings at conferences (e.g., PME, PME-NA), where knowledge is being shared so that more practitioners benefit?

How can we integrate the work and tangible artifacts of the vMEC into the sMEC?
How can we value open access to a level similar to academic rigor?
How can we change the systems to focus on access and research, particularly for communities beyond the sMEC?

In some ways, being a fox counters the very nature of the academy, which supports and rewards hedgehog work. In this sense, the only way those in the sMEC can do foxy works is to be a rebel. A member of the sMEC may not feel it financially or personally worth it be a rebel; but, ultimately to engage in fox-like work, a member of the sMEC needs to push back on the closed systems that dictate hedgehog work.

Concluding Remarks

We affirm the need for more foxes in mathematics education (Boaler et al., 2013; Kilpatrick, 2013); we highlight that the calls are not individualistic, but collective. We emphasize structural concerns of the closed, hedgehog system that we reside in within sMECs. And, we hope that our field can begin the challenging, deep work of systemic change that encourages a skulk of foxes.

We recognize that there are challenges in using a strict dichotomy to describe mathematics education communities of practice and their members as either hedgehoges or foxes. Within a community, members might position themselves and their work along a continuum from all-fox on one end to all-hedgehog on the other. However, we contend that examining communities (vMECs, sMECs) through the lens of foxes and hedgehogs offers a way to re-examine and re-frame scholarly spaces. In doing so, this perspective incorporates a social justice stance that allows for examining institutional structures, practices of community engagement, and teaching and learning environments (NCSM & TODOS, 2016). Thus, by adopting this lens we can consider individual actions and identity the institutional and contextual factors that may support or constrain one's work along various points in the hedgehog-fox continuum.

The vMEC and the sMEC have differing expectations about knowledge, knowledge creations, and access to knowledge within their communities of practice. These differences dictate the type of work, hedgehog or fox, which occurs. The sMEC, with marginal involvement in virtual spaces, has different ideals of what constitutes transformative work. Boaler and colleagues (2013) challenge scholars for intentionality in reaching out to differing communities. The very nature of the expectations in the sMEC limits what those in the academy consider and value as transformational. Those in the vMECs preference open access are inherently foxy communities of practice (Berlin, 1953; Boaler et al., 2013). In the shared virtual spaces—i.e., Twitter, Facebook groups, Instagram—communities formed around shared domains with engaged participants who wish to evoke change. This constitutes sharing things in public, free, open-source ways. Even if members of the sMEC remain dedicated hedgehogs, we believe they should spend more time within social media platforms and begin to participate with active members of the vMEC. In this way, members of the sMEC may play a more active role in transforming these virtual communities and shaping the field in the future.

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