Driving Reform through Communities of Practice in Scientific Fields

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Abstract: Humans learn through social interactions therefore it is not surprising that we create around ourselves social structures that guide and support our learning as well as our practice. Communities of practice are one such social structure that exists within fields of science. Understanding the secondary cultures that are represented in the epistemology, practices, and perceptions of each field can help us better approach reform in fields using communities of practice as a starting point. The intersections of communities, culture, and change represent challenges to reform in education that should be explored and leveraged.

Keywords: *Communities of practice, education reform, science.*

Introduction

Since the first communication, people have been coming together to combine their knowledge to solve problems. Vygotsky explained this as human nature, that people are social creatures by nature and learn through social interactions. Nowhere is this more apparent than within the context of communities of practice. These maintained learning communities can be used for everything from professional development to solution development and can be a valuable tool to professionals in their fields. Research has been conducted to explain, model, and evaluate learning communities or communities of practice with a focus being on what they are and how they work (Dooner et al., 2008; Lemke 2001; Wenger 1998, 2006; Wenger et al., 2002). The need for such is explained in the idea that "learning cannot be designed; ultimately, it belongs to the realm of experience and practice" furthermore," there are few more urgent tasks than to design social infrastructures that foster learning" (Wenger, 1998).

One aspect that has not been studying in such depth is the interactions among members and how the culture of the individuals involved influences those interactions, expectations, and general behaviors. In discussing culture, it is not the racial, ethnic, or regional culture of interest, but rather the secondary culture that comes from being a member of a specific field of study or discipline. Worldview of the individual is important but so is the larger culture that exists within fields. Therefore, understanding these perspectives regarding the greater community is imperative (Wenger, 1998). Hence, the idea that secondary cultures can impact scholarly interactions is not a foreign concept but a further exploration of the depth to which culture drives us on an individual level.

In this commentary, we examine expectations, positions, and interactions of university faculty members in multi-disciplinary communities of practice. These communities consist of university faculty in both science and education fields with representation in multiple sub-disciplines such as curriculum and instruction, technology, mathematics, life sciences, and physical sciences. The expectation is that the epistemology and overt practices specific to each field of study have observable implications regarding how the members seek to voice concerns, their ideas regarding what changes are essential, and how to bring about the desired change. Understanding processes of change and change-bringing bodies such as communities of practice is imperative in today's society, especially in the scientific field. Lemke (2000) addressed this by saying we should engage a "sociocultural perspective on science education," saying that we must "view science, science education, and research in science education as human social activities conducted within institutional and cultural frameworks" (p.296).

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The present movement in education and the workforce builds upon the concepts of discovery, inquiry, and the ability to solve problems and work with teams to improve performance. Change has to occur in how we are preparing students to address these issues. One particular focus is reform in science education, where the opportunity to learn discovery and inquiry methods is imperative for a scientifically literate society (e.g., Gess-Newsom, Southerland, Johnston & Woodbury, 2003; Sunal et al., 2009; Weld, Ophus, & Hanna 2009). One method implemented to address reform is the creation of communities of practice among science professors, science educators, and science teacher educators to align goals across levels, establish resource pools, and device methods by which change can occur. To formulate models and guidelines to aid in creating such communities, we must first understand how these communities work on a smaller scale and what factors influence their performance. It is not complicated to come together in small learning groups with persons of shared interest and background. However, the concept becomes more complicated in real-world applications where often the members who come together to combine knowledge, share resources, and generate solutions are from widely varied fields, levels of expertise, and both primary and secondary cultures.

Literature Review

In the past thirty years, the concept of culture has moved to a position of great importance in education. Numerous studies examine the role of culture in learning with culture taking on the persona of community interactions. Culture represents sets of beliefs, behaviors, and ideas shared among members in a group. In his text on cultural psychology, Heine (2008), specifically defined culture as "any kind of idea, belief, technology, habit, or practice acquired through learning from others" (p.3). These elements are the definition commonly examined in research regarding learning. However, most of the cultures of focus are taken from the racial, ethnic, or sociological point of view, not from the viewpoint of a culture-across-cultures viewpoint. Due to the nature of the literature and minute amount of data gathered that deals explicitly with scientific cultures in communities of practice and how those cultures influence the members, research data has been collected from sources that are parallel to the topic, or bisect communities of practice, culture, science reform, and epistemology.

Culture is such a significant factor in the lives of human beings that an entire field of science is devoted to studying these interactions. Anthropologists have long sought to understand how social behaviors impact society and recognize these microcosms to be of great importance both developmentally and structurally. What we learn from these studies is that our culture directly influences our behaviors, expectations, and beliefs. With this noted, culture extends beyond the first groups to which we belong to those we choose for membership. Culture herein extends to all groups in which we have shared practice, especially those relative to our chosen fields of study. Bruner (1996) evaluated culture as part of the formation of the mind, and thus a key to how we learn. Considering that cultures are essential in education reform, each person has a history of learning, which works, in effect, like a blueprint for their expectations of learners. Knowing that learning is social, we can look beyond the culture of learning from a personal origination viewpoint and examine how every culture in which a person becomes ensconced influences their perceptions and expectations for learning.

It is important, therefore, to explore the influence of cultures that operate across these traditional boundaries and are, in a sense, secondary cultures to the participants. These would be the cultures of the disciplines, meaning the expectations, behaviors, and beliefs shared among members of specific fields of study. In this case, the secondary cultures of the individual participants in communities of practice geared toward science education reform. Each member of these communities, regardless of their primary cultural background, carry with them the culture of their respective discipline. Represented in the groups are pure scientists from fields such as biology, chemistry, and physics, with various sub-disciplines as well as science educators. It is important to note that this commentary focuses on the cultures of the individual's discipline, how those cultures manifest in the interactions among members, and how the cultures influence member's perceptions or expectations regarding reform in science education.

Focusing on the field instead of the learner requires defining the culture at the professional level beyond the social. From this angle, culture represents "aggregate patterns and dynamics that are on display in expert practice and that vary in different settings of expertise" (Cetina, 1999). Using this definition, we can examine how members of specific disciplines become part of a secondary culture via their training, participation, and acceptance as part of the field of study. The author further describes the sciences themselves as many divided cultures, with each branch holding its own "machinery of knowledge construction," that science itself is a field not unified in practice or design (Cetina 1999). Science separates into two broad general categories, the natural or life science and the physical sciences. Each field subdivides into any imaginable number of subfields, each of which has its own diverse set of norms and behaviors. For this investigation, examining the sciences through a more macroscopic lens, with some focus on the specific habits attributed to individuals based on their specific topics of expertise within their discipline. We will consider the general categories of biology, physics, chemistry, and the environmental sciences.

When dealing with groups of individuals in the sciences, it is crucial to note that there is an existing gap between those considered scientists and those called science educators. Lemke (2000) established eight questions regarding the nature of science and education. They gave that charge that they are answered from the perspective of science and science education, recognizing a substantive difference in how each conceptualizes knowledge and the processes of

learning and that sciences cannot be generalized. Each science is a body in and of itself, as different in epistemology and culture from the other sciences as it is from the field of education that it seeks to aid in reform.

Cetina (1999) took the time to investigate the cultural differences between members of the biological science community and the physics community. The most striking observation was how they acquire and disseminate knowledge. In short, those in the field of biology were more likely to work in solitary conditions or among a select group of peers to gather data and make observations. They were also less likely to share information before public sharing through means such as publication. In stark contrast, those in the physics field, especially her observations at the CERN research facility, were more likely to operate in large groups of peers with representation across sub-disciplines. The amount of sharing of both knowledge and resources were exponentially more remarkable than that of the other field. Therefore, at the root of the community, some fields by culture would be more likely to participate and actively engage in communities of practice than others. The existence of specific cultures among disciplines can affect if and how members are part of these processes.

Two fields that highly differences in culture are structural chemistry and experimental physics (Cetina, 1999). To understand fields, we must look at their epistemology, knowledge generation, and methods of approach. Kuhn (1996) best embodies the concept of scientific research, detailing that scientists do not set out to find new things, but rather operate within existing paradigms of knowledge, and, more often than not, the discovery of some new phenomenon is purely the result of accidentally garnering unexpected results when testing known phenomenon (Chapters 1 through 7). Scientists, in general, hold themselves and their peers within sets of boundaries unique to each field and the paradigms that formulate accepted knowledge and principles within that field. Through extended interviews and observations of interactions among members of cross-disciplinary, science-reform charged, communities of practice, it is expected that connect the community activities to the individual member's secondary cultural beliefs and expectations.

Methodology

Research Goal

The goal of this discussion is to frame the need to explore interactions of different cultures of existing communities of practice and the role they play in driving reform in STEM education settings where interdisciplinary communities are being built.

Result and Discussion

Intersecting cultures impact education reform

Reform in any area is a cumulative process that comes about through careful coordination among stakeholders. "Reforms that seek to change the fundamental structures, cultures, and pedagogies in schools are inherently difficult to implement and sustain," according to Cuban 1988 (as cited in Gess-Newsome et al., 2003). Education reform is no exception. With stakeholders at every level of education, both as students and instructors, and society itself, it is vital to have representation in the reform process to enable smooth transitions between levels. Weld et al. (2009) examined the variation of goals across the secondary and post-secondary levels identifying gaps in goals and expectations between the levels by surveying 6000 educators throughout the United States (p.2). They noted incongruence between the secondary and post-secondary goals and a complete lack of agreement on goals among the disciplines at the post-secondary level (Weld et al., 2009).

Across the research, there is a pattern of expanding the traditional idea of the learning community into a body used to bring about growth and change. Brooks (2010), noted in research to establish a faculty community model, that fostering community to bring about long-term changes in higher education is supported by a growing volume of evidential research (p.263). The criteria for reform place much focus on the need for support, communication, and continued evaluation, especially in the area of science education reform, so this method can address each concern while allowing input from stakeholders involved. What is unknown is how to create a specific but nearly universal model for these communities that apply to most groups.

Many models for reform and communities exist, but most are limited in application to other groups. Gess-Newsome et al., (2003) confirmed this in their generation of the Teacher-Centered Systemic Reform model (TCSR), a reform model generated from within-case and cross-case study data in a four-year post-secondary science program. One aspect that plays into this difficulty is the background of the membership, specifically the cultures that dictate the expectations and approach of members of a specific field. Further exploration of epistemological foundations is needed to understand why this could be an influential factor. Based on the demonstrations of these patterns of dissemination, interaction, and structure, one's field culture may play an integral role in how they approach and seek to bring about reform.

Changing teaching in the classroom has no lasting effect if the programs that train the instructors are not also adjusted to reflect the same change. This concept "smooth handoff" was addressed in a study by (Weld et al., 2009) in which they likened the transition across levels to running a relay race (p.1). The concept explained was that each leg of the race is only one piece of the big picture, so there must be a smooth transition. A team of the best runners in the world is

virtually useless if the baton drops in their transition. Details are a challenge in education reform. Thus coordination across levels must be a critical factor in the selection of goals and approaches to change. In their study on undergraduate science reform, Sunal et al. (2009) identified eighteen criteria for bringing about change based on a national survey of higher education institutions (*n=103*) of differing Carnegie classifications (p.13). Among these criteria were nine criteria directly related to communication across levels of expertise, sharing of knowledge and resources, and continual learning for improvement (Sunal et al., 2009). These criteria, in short, represent the community of practice.

Communities of Practice can drive reform

Wenger (2006) describes a community of practice as a group of people who come together to learn to share resources and knowledge in a shared field of interest (Communities of practice, paragraph 1). Communities of Practice are different from a meeting of friends or compatriots in that the model requires three conditions; domain, community, and practice. The research further established that communities of practice require three collective pieces: a community, a domain, and practice (Wenger, 2006). It is important to note that only bringing people together does not constitute a functional community of practice. Communities are first built by trust then members must come together with varying levels or fields of expertise in the agreement that they will seek answers to a shared problem. In short, they must have purposeful interactions among group members and shared goals.

The domain is an area of interest in which the members of the group have some commitment and expertise; in this case, the members are all experts in their fields, but the domain would be science education reform, a topic in which each has a vested interest and experience. Finally, there is a practical requirement. Wenger (1998) addresses explicitly practice as being "first and foremost a process by which we experience the world, and our engagement in it is meaningful (p.51). Simply gathering with a group of peers does not constitute practice. It is the "shared repertoire of resources" from the members as practitioners that enables the group to take action in some given direction, in this case, solving problems in science education (Wenger 2006).

Patterson (2002) explored the issue of reform through a lens of culture and how the cultures of the participants is directly tied to the design, implementation, and acceptance of reform; noting that "reform often has more to do with professional values and belief than what are known to be effective practices"(p.68). Since reform centers around the remodeling of "structure, culture, and pedagogy," understanding the background of community members in regard to these points is key to identifying how they will approach the change and what changes they will see as mandatory (Gess-Newsome et al., 2003). Wenger et al. (2002) have dedicated a novel study to the cultivation and continued maintenance of communities in business, education, and society that support the idea of communities of practice being a method of measurable success for reform (Chapters 1, 8 & 9). The community of practice approach to reform in science education is one that enables stakeholders from all levels to get involved in the process of deciding upon shared goals and methods. It adds to that change ideology the ability to institute change at both the organizational and beyond since the involvement of post-secondary science and education faculty would enable change in the training of the next generation of science education leaders. The inclusion of members enables a reform approach specific to the needs of both the members as well as problems too very area or district-specific concerns and shortfalls.

Conclusion

The bodies of research surrounding communities of practice, reform, and culture provide clear operational definitions of what each entity represents as well as a general overview of how each has a place in science education. How these three entities interconnect, with each being altered by the other, is missing in the big picture. In the literature, we see how communities of practice can unite stakeholders and shift ownership of the reform process to members across levels. We see how primary culture is a critical influencing factor on how we learn, what our beliefs are, and how we approach the world as well as how the idea of our chosen field of study can operate as a secondary culture as we become ingrained within the constructs of both the behavioral and epistemological norms of that field. It is not a stretch then to expect that some interaction takes place between that secondary cultural construct and the methods, expectations, and general approach a participant undertakes in regard to membership in a reform community of practice. Within large communities of practice where there are shared goals but varying levels and fields of expertise, there exist differences in how each member approaches the reform process as well as what their expectations are for change. Based on this assumption, the need to understand how that culture influences these interactions can help us better understand how certain aspects of our secondary culture drive us to interact with others to bring about change in science education.

Suggestions

In creating STEM communities, it is the position of this researcher that time first be spent defining and sharing about the initial communities of practice that exist in the component fields. Understanding the cultures, expectations, and practices of the individual fields makes possible the creation of a novel integrated community of practice where the goals, roles, expectations, and processes are clearly defined and vision for the community is shared in the way that it is

within individual fields. Failure to examine the roles existing cultures of community play in the creation of interdisciplinary communities can lead to failure to maintain the community or reach the goals that have been set forth.

Limitations

As with all processes and designs, there are limitations to the use of communities of practice. Dooner et al. (2007) mainly focused on the realities of learning communities, noting that because a universal model does not exist, "group members are often unprepared, and then frustrated, by inevitable group tensions" (p.564). As with all reform efforts, communities take time to build trust, establish shared goals and learn to work together effectively. Thus it is often vital to have a unifying event or series of actions to foster the sense of community (Dooner 2007, p. 568). Wenger et al. (2002) devoted much time to the downside of communities of practice, especially those whose purpose is neither fostered nor maintained, citing "they can hoard knowledge, limit innovation, and hold others hostage to their expertise" (p. 139). narcissism, marginality, and factionalism. However, most limitations are addressable through continued maintenance and development of communities of practice.

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