The transformation of scientific information through artifacts

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Abstract

We use artifact analysis to describe the process of scientific dissemination in a community-based program that informs parents and professional caregivers about early childhood development. We define this program as a network of information management and our unit of analysis are the sociocultural activities of dissemination, and the artifacts that shape them. Drawing upon activity theory, social networks theory, and distributed practice, we describe and analyze the impact, evolution, and sociocultural nature of understandings, goals, values, artifacts, actions, events, and organizational elements. Our data were collected through observations, field notes, focus groups, artifact collection, and stimulated recall interviews. Results suggest that as artifacts move from one environment to another, their role changes, often resulting in a loss or distortion of information. We describe how and why these problems are overlooked and the potential problems they may create.

Studies of scientific dissemination are rich sources of information about cognitive processes situated in a sociocultural context. The dissemination process has been almost completely the domain of large corporate, government, or academic entities—universities, pharmaceutical companies, the National Institute of Health, media networks, and the like. The role of lay people and their communities has been largely one of end-user, with the assumption that they could be expected to act as recipients of information rather than disseminators; a passive role at the bottom of the organizational structure (Epstein, 1996)

The importance of community involvement in education, advocacy, and decision making has been growing over the past decade (Minkler & Wallerstein, 2002). At the local level, the project team identifies community needs through community engagement (Minkler & Wallerstein, 2002), an approach to research and intervention characterized by its use of the community as a unit of identity, action and analysis. Communities may be formed around geography, socioeconomic status, shared emotions, or common goals. Facilitators are community members who bring scientific information to the attention of local end-users, translate concepts and terms, and help end-users apply the information in making personal decisions.

Facilitators can also inform disseminators and scientists about end-user interests and needs; thus, ideally, information can flow in both directions. However, facilitators need aid in finding and organizing information, contextualizing scientific findings, applying them to local situations, providing emotional support, and serving as advocates and spokespeople. In short, facilitators need support to provide support, in terms of content, culturally relevant delivery, and information management. There is growing evidence for community-based dissemination, scientific communication that is culturally responsive, accounts for audiences' prior knowledge and ability/willingness to acquire new knowledge, and is flexible enough to fit diverse goals, resources, and interests. (e.g., Minkler & Wallenstein, 2003; Shonkoff & Phillips, 2000; Wilcox, Hadley, & Bacon, 1998).

This creates interesting questions regarding reasoning in community engagement setting, especially in regard to facilitators and outreach personnel. They are, on a number of dimensions, in limbo. Regarding the scientific content, they are neither experts nor novices; they usually have some teaching or outreach experience, but they often have never functioned in this role with this population before. They are engaged in scientific dissemination, but they are not part of the groups usually studied in the context of dissemination studies, such as scientists, media, or teachers.

Research on community-based interventions also offers interesting opportunities for dissemination research. A main reason is that facilitators are engaged in a process that requires a quick turnaround; their training may last few weeks or months and they are soon ready to work in the field. Updates, refresher courses, and additional training are put to work within a similar timeframe. This allow us to watch the inflow and outflow of information in a way that we cannot with dissemination agents whose timeline involves years of training or experience, such as a journalist, scientist, or social worker.

In short, community engagement and community facilitators are playing an increasingly important role in scientific dissemination, they are unusual in a number of ways, and they also provide opportunities to watch the dissemination process in a compressed format. Of course, this can both create unusual patterns and behaviors that are not seen in other areas of dissemination, but it does not necessitate uniqueness. Therefore, it is initially important to examine the ways in which this format repeats patterns in other spheres of scientific dissemination, and the ways in which it reinvents these patterns or creates new ones.

To construct a framework for this comparison process, we draw upon multiple streams of dissemination research in attempting to cover the ambiguous position of facilitators

and community engagement. This includes novice reasoning about scientific information in structured settings (Sandoval, 2003; Schank & Ranney, 1995), and informal settings (Zimmermann, Bisanz & Bisanz, 1998), lay advocacy and policy involvement (Epstein, 1996; Margolis, 1996), scientists reasoning among themselves (Latour, 1987), and interactions between lay people and experts (Lemke, 1990). Using this framework, we examine a community engagement program providing parents and professional caregivers with information about new psychological and neuroscientific research on early childhood learning and development.

Sites & Program Description

The program that we have been following, *The First Teacher Project* (*FTP*), is part of a larger initiative started in the city of Chandler, AZ in 2002, *The Steps to Learning Initiative* (*StL*). Funded by an Early Learning Opportunities Act Grant from the U.S. Department of Education, *StL* was created to educate the community about the importance of early literacy and learning, develop stronger links among service providers working with children and families in the Chandler community, create a comprehensive network of early childhood programs, and make information and programs more affordable and accessible. The grant was secured and is overseen through the Mayor's Literacy Task Force, and administered by the Chandler Public Library. Other partners include the Chandler Unified School District and the Chandler (East Valley) Regional Hospital.

Chandler is one of the fastest growing cities in Arizona, with a large traditionally underserved population. In the 2000 Census, Chandler had one of the largest Latino populations in the state, ranging from 25% to over 50%, depending on neighborhood (Morrison Institute, 2001). It is also an economically diverse city, home to Intel and Motorola, but also to a federally-designated Enterprise Zone. Eighty percent of Zone residents are Latinos and 68% of households are monolingual Spanish. Seventy percent of students qualify for free or reduced-price lunch, 50% of families earn less than $5,000/year, and almost 50% of adults lack a high school diploma.

The *FTP* component of *StL* focuses on children's development from ages 0 to 3. The program focuses on sensory development, bonding and attachment, cognitive skills such as categorization and language, and the value of play and pretense. The information provided can be used to identify developmental delays, sensory deficits, and other problems early on, as well as providing parents of mainstream children with new perspectives on their children's learning and development. *FTP* involves disseminating a significant amount of scientific information, much of it relatively new even to scientists in the relevant fields. Topics include neural pruning, synaptic formation, plasticity, limbic and cortical functions, biological and psychological aspects of temperament and language acquisition.

The *FTP* initiative is coordinated by a full-time outreach coordinator. A group of 12 paid community professionals (eight educators, three librarians, and the outreach coordinator) receive forty-five hours of training, and conduct mock workshops before beginning to facilitate parent workshops in their schools and libraries. Facilitators receive continuing education on a monthly basis, and have committed to a tenure of at least 18 months. *StL* is currently looking for ways to fund and support the program beyond this 18 month timeframe.

Activity, Artifacts, Dissemination & Education

In addition to setting up a content framework, we need also to construct an epistemological and methodological framework for the analysis. We do so in a hierarchical fashion.

At the highest level, we have chosen to adopt an activity theory perspective. In activity theory, the unit of analysis is continually developing activities—events, transactions, practices—and the analysis is organized around objects that motivate, guide, and give meaning to activity. Objects have both physical and semiotic properties, and affect human interactions with their environment, as tools for physical and mental activity. Because of activity theory's emphasis on social factors and the interaction between agents and objects, it is useful for capturing the process of scientific dissemination, the practices of which depend heavily on tools and networks of social interaction.

In identifying objects that organize events and transactions of importance, we use Latour's concept of artifact (Latour, 1987). It is a fairly broad conceptualization of artifact, in which artifacts are physical entities that have been given meaning by human beings through utilization and construction.

Using this artifact-oriented approach to examine the dissemination of scientific information, specifically in the context of educational dissemination, and compare our findings to the existing research in other areas of scientific dissemination. Based on this analysis, we find that the scientific content is altered by organizational goals, available materials, etc; that it is important to distinguish explicit, tacit, and incidental features of artifacts; and that the distinction between the "scientific content" of the artifact and elements added during these alterations is often not identified by facilitators and parents.

Method

In this study, we take the perspective that the *FTP* can be conceived of as an activity system with the primary purpose of knowledge management and community dissemination. Drawing upon concepts from activity theory, social networks theory, and distributed cognition, we describe and analyze the development and consequences of stakeholders' understandings, goals, values, artifacts, actions, and organizational dynamics. We collected data over the full 18 month existence of the program, using observation, video recordings, field notes, focus groups and stimulated recall interviews, artifact collection, and surveys.

Extended observation and videography was conducted throughout the life of the program; all training sessions and most of the parent workshops were observed and/or recorded, and most of the ongoing monthly meetings have

been observed. In addition, several meetings of the grant oversight committee, the Mayor's Literacy Task Force, have been attended by at least one of the authors. Field notes provide in depth descriptions of activities, settings, and interpersonal dynamics, were the only means of establishing a record of events where we were not granted permission for videography, or when it was not appropriate to record a particular event.

Focus groups with the facilitators took the form of discussions that allowed us to collect information about their perspective, and the meaning they attached to particular artifacts and events. Video-elicited and artifact-elicited interviews are used to obtain an in-depth perspective of the local meanings teacher create in relation to key perceptions, goals, experiences, actions, and elements of this program.

Artifact collection and documentation refers to the process of gathering/recording objects and conceptual symbols. Artifacts are objects that have both material and conceptual characteristics and that have been transformed through the history of this program. This category includes curriculum binders, slides, handouts, props, toys, logos, memos, announcements, electronic newsletters, websites, acronyms, jargon, and definitions.

Content area questionnaires are used to assess teachers' knowledge of infant brain development before training began, and at intervals after training. These assessments include fact-based, open-ended, and problem-solving items. A separate motivation survey was designed to address affect and efficacy in relation to distinct aspects of participation; training, instruction, curriculum materials, trainers, and programmatic characteristics.

Results & Discussion

The *First Teacher Project* is best described as an activity system configured into a dynamic network of information management. This network relies upon the interconnection of different levels of cognitive mediation (e.g., object, social, organizational). Our analysis is primarily based on the study of how these mediations become embodied into the conceptual to material continuum of artifacts. We use Collins et al (2002) hierarchy of mediating artifacts to categorize *what, how, why,* and *where-to* artifacts. The *what category* refers to artifacts that serve as a means to achieving an object (e.g., using chart paper to write down parent questions). *How* artifacts contribute to understanding how to achieve purposes or goals (e.g., using a case study to demonstrate how routines help babies). *Why* artifacts motivates achievement of the goal (e.g., presenting statistics of neglect and abuse linked to academic achievement to encourage parent-child bonding). *Where-to* artifacts motivate the evolution of all activity elements (e.g., identifying a pocket population that was not targeted and re-defining main project goals).

Artifact analysis is primarily an in depth description of the history and meaning of tools and signs that evidence intentionality and activity of agents within this network of information management. Artifact analysis is a process of analytic induction that focuses on how artifacts evidence actions that occur in specific settings and in connection to specific meanings. We use Erickson's (1990) five methods of evidentiary inadequacy to determine the degree to which we have a) adequate amounts of evidence, b) adequate variety of evidence, c) trustworthy evidence, d) adequate disconfirming evidence, and e) adequate discrepant case analysis.

An example of an artifact is the brochure community professionals put together to attract participants to the parent workshop. At one point, this brochure may represent everything target parents know about the project. However, parents are unaware of the history of this artifact, how the printed language reflects interpretations of science, how explicit goals of the workshop relate to assumptions about needs in this community, or how this workshop expects to influence parenting. The brochure is a byproduct that reflects negotiated goals, program priorities, perceptions of the target population, and a way to sum up the essential components of a newly developed expertise. The final draft of the brochure is edited by the project coordinator after asking community professionals to develop drafts, after discussing these drafts during taskforce meetings, and after receiving approval from all stakeholders. In this way, the development of a simple communication product is informative of the way this project is represented to the larger target population, the role of distributed cognition and distributed practice, and the protocols and the organizational structure necessary to develop this double-sided page. And the workshop brochure is just the entry point to the vast world of artifacts that are part of this BBE curriculum. As the parent arrives to the actual workshop he/she will be exposed to graphs, binders, slides, toys, props, sounds, video-clips, case studies, analogies, metaphors, acronyms, jargon, and abstract ideas.

It is important, too, to recognize that artifacts are not necessarily bounded physically, but by the role they play in a network of activity. We address this in our analysis by examining agent-artifact units, i.e. units comprised of an artifact and the agent who is currently making use of the artifact. Thus, a brochure handed to a parent by their child's teacher is a different agent-artifact unit than a brochure taken from a stand at the door of a library.

Content transformations

The main goal of the *FTP* is to translate neuroscience into recommended practices that will improve parenting and normal child development outcomes. Research techniques and directions, however, often do not directly support this goal. Much of the neuroscientific research available, however, has been conducted using deficit models, and highly constrained tasks and environments. Therefore, application to normal developmental practices is rarely an explicit element of the scientific report. Thus, when a report in a journal is read by a curriculum developer, the developer-report unit is a different entity than the scientist-report unit, and the report is used for different purpose (developing parenting recommendations vs. informing peers of experimental results), establishes credibility in different ways (appearance in a prestigious journal vs. surviving the actual peer-review), and becomes a symbol for establishing

authority rather than a document containing information to be examined.

The effects of this transformation are several. One way in which this is done is through broad generalizations into maxims that would be difficult to find objectionable. Statements that encourage parents to provide a stimulating but not overwhelming environment, to not neglect their children emotionally or physically, to create a loving and protective environment. The training providers believe that by taking these unobjectionable messages and pairing them with laboratory research that is tenuously connected, they will make these messages more persuasive by making them more authoritative and making them appear to be based in "science."

Another approach is to take deficit model findings and transform them into "best practice" recommendations. The logic, roughly, is that if the absence of certain elements has a deleterious effect, then parents should be encouraged to make sure these elements are present. While this is not always faulty logic, it can at times produce the implication that since less is bad, more is better, and that greater amounts of play, visual stimulation, exposure to human faces, and so on, will have a beneficial effect beyond that which normal caregiving would provide. Research studies based on abnormal case studies produce dramatic research findings on how neurological disorders, neglect and abuse can adversely affect brain development. However, this program is not designed to target parents of children with major disabilities, but to target the general population. In this way, research findings from deficit models are discussed outside of their context, and derived applications may involve unwarranted alterations of the science content. For example, facilitators are taught that physiological and psychological traumatic events can chronically elevate an individual's cortisol levels, which in turn may result in the destruction of neurons or a reduction of synaptic connections. Children who have high levels of cortisol in response to trauma have been shown to experience more developmental delays (Gunnar, 1996). A key artifact here is a video-clip interview of neuroscientist who explains how cortisol levels show how the brain responds to stress levels. In the context of a parent workshop or facilitator training, this functions not so much as a way to deliver information but to prove the curriculum's scientific backing. That sustained high levels of cortisol can cause delays does not imply either that transient elevation from minor stresses will cause problems, nor does it imply that extremely low stress will facilitate development. With community facilitators there is a tendency to blur two distinctions: the difference between stress and trauma, and the distinction between temporary and permanent changes in cortisol levels.

The content may also be transformed because of the physical constraints imposed as artifacts are paired with new agents. An example is the inclusion of infant massage experiments in the curriculum. A meta-analysis conducted by the Cochrane Review found the evidence to be weak, though in the direction of supporting the use of massage with infants receiving neo-natal intensive care (Vickers, Ohlsson, Lacy, & Horsley, 2004). Findings regarding its use in other areas appear likewise ambiguous.

Those experiments supporting infant massage as beneficial are incorporated into popular books (e.g., Field, 2000) by clinicians and researchers that wish to make their case with the public. These are then taken by curriculum developers and integrated with specific *how-to* activities and instructions that guide parents into giving leg, foot, arm and hand, face and head massages to infants. *How-to* activities often have not been equally researched, though this distinction is not made in the materials given to facilitators during training. A focal artifact here is a written description created by the curriculum developers where they describe that, ideally, parents are to take into consideration the age of the child to determine the type, duration and frequency of massaging a baby: A massage for a newborn baby should be limited to 3-5 minutes, while a month old baby can receive a 10 minute massage. In addition, it is said that parents should be attentive to determine individual differences in responding and tolerating touch. When the community professionals attended their training, these written instructions are verbally described by the trainers who also modeled concepts by using realistic baby dolls. Participants practice the massage on these dolls, which then become part of their representation of infant massage.

However, the specifics of the infant massage curriculum are not covered in the same fashion by facilitators as they bring this information to parents. The infant massage demonstration and hands-on activity is time-consuming, so the facilitators do not have the same opportunity to emphasize this topic as do the developers. Moreover, they have only one doll, making even demonstrating to a group somewhat difficult. The facilitators rely on slides showing bullet points that summarize the main ideas on how touch enhances bonding. Moreover, we observed that discussions often wandered onto interesting but misleading tangents, such as formal training in infant massage therapy. The superficial overview in the context of such a discussion is misinterpreted by some parents as a need to seek a special training. There is not a deliberate plan to distort information, but the way information is presented has an unexpected effect.

Artifacts & Expectations

During the initial intensive period of training, *NDI* structured the content of its curriculum around two acronyms *STEPS* for security, touch, eyes, play, and sound and *ABC*'s of learning for attention, bonding, and communication. These acronyms were developed as a way to organize the curriculum, and resulted from feedback of prior *FTP* programs that had been implemented in different communities. Those prior programs received a similar training with very little organizing structure, and limited curriculum materials. *FTP* trainees received a binder with five major divisions that corresponded to the *STEPS* acronym, their training was structured around these topics, and each of the *STEPS* concepts was discussed as relating to the *ABC*'s. In addition, *NDI* developed a wide array of materials that included slides, power-point presentations, video-clips and activity sets called the brain boxes. In turn, the facilitators structured their first parent workshop series as five meetings, each of which reflected the *STEPS*

structure. The different sites reported that five workshops proved to have a high turnover, and *StL* decided along with *NDI* to structure the curriculum around 3 meetings. Then, the curriculum started to be reorganized around the *ABC*'s as the guiding acronym, with the *STEPS* concepts subsumed. These acronyms are artifacts that reflect which concepts are central to *NDI*, how those concepts help organize activity, and the affordances those acronyms have. These acronyms are just one way of organizing knowledge that links neuroscience with parenting and child development, and they in fact seem to be useful in organizing workshops and discussions. Our preliminary findings suggest that these acronyms act as a paradigm through which experts, trainees, and parents think about and recall infant brain development information. For example, during a focus group activity we asked facilitators to write down which are the most compelling ideas they take from this training, and most participants referred to the acronyms. Other ways in which this acronyms influence information management and distributed cognition is that they implicitly convey the idea that these categories are all encompassing, and that scientific information is stable. We discuss these ideas further in the next section.

Artifacts may set up expectations because of their appearance or immediately perceived function. If they are improperly designed, or if the design is misinterpreted, problems can occur. To illustrate this point we refer to the script NDI puts together for facilitators to guide their presentation as they conduct the parent workshops. The script is text that corresponds to a particular slide and elaborates the main ideas represented. The parent workshop is usually structured around a series of slides, and the series of slides are connected through an overarching curriculum concept (e.g., security, eyes, touch). Most facilitators plan their parent workshops by reviewing this script, and they often refer back to the script as they conduct their presentations. This way of implementing the workshop is efficient in conveying many concepts to the parents who are part of the audience, and it also creates consistency and a good point of reference across facilitators. On the other side, the script winds up dictating most of what is said during the parent workshop. The script sets the tone for the presentation of information slide after slide, with facilitators either rephrasing or reading off the script. As a result, it is not infrequent to observe that the workshop is run as a forty-slides presentation with very few questions asked. Therefore, the script drives the workshop, leaving a small amount of time for unscripted events, which is taken up making introductions, allowing for breaks, doing take-home activities, and checking out materials.

Furthermore, the script and slides seem to endorse the perception that these curriculum materials are a self-contained representations of brain-research; sufficient to achieve the main goals of the workshop. Facilitators do not feel the need to continue exploring the science beyond this point. During continuous support meetings, NDI has emphasized the importance of speaking more explicitly about the specific brain research facts and language. Facilitators try to adjust by using the language that is part of the script, but do not go beyond this information.

As facilitators become more experienced in conducting the parent workshop, however, they take greater ownership of the content. They rely less on the script and make use of personal examples that have been effective in the past. Still, when parents ask questions that relate to more specific details of the research, facilitators have difficulty addressing those questions. A parent asked how scientists know that children see blurry at first and they see faces very clearly around three months. Even though an explanation of techniques used to determine babies' responses is provided for facilitators, they only seem reliably aware of the information presented through the script. They have a very hard time addressing those issues if they feel the question must have a right answer that is lying somewhere in a library. Facilitators are often more successful if they can find examples that relate to their own personal experiences as caregivers or teachers. They are capable of finding connections that are relevant and that help illustrate the main points, but when questions are asked about the scientific content that cannot be grounded in case from their experience, facilitators quickly face difficulties.

Conclusions

The unique characteristics of community based programs for the dissemination of scientific information include a rapid training turnaround and the opportunities to document how science concepts are transformed through actions, objects, social interaction, and organizational elements.

Community-based programs for the dissemination of science are complex activity systems that manage information in ways that reflect elements such as organizational knowledge, learning, and culture. In this particular case, the *FTP* program based high-level goals by presenting them as truisms that are difficult to challenge (e.g., parents should create a loving environment), while tacit low-level goals go underdetermined (e.g., research based on deficit models is applied to the general population). As a result, neuroscience is translated in ways that bypass issues of ecological validity.

Artifacts with flawed designs, or artifacts that are misinterpreted are likely to create problems that can go unidentified. Scripts that are meant to guide facilitators end up dictating the pace of the parent workshops in ways that limit parents' active participation, and in ways that communicate to facilitators that these materials are a finished-all-inclusive product. Finally, the development of artifacts such as communications (e.g., newsletters, brochures) give insight into how goals are proposed, negotiated, and enacted. This analysis also illustrates how the entire system works as a network that manages information.

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