Informal Science Learning Environments:

A Review of Research to Inform K-8 Schooling

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The purpose of this paper is to review what is known about informal science learning and to recommend areas for further research. The review is intended to support an examination of how children's science learning experiences in designed informal environments like science museums and zoos relate to science learning activities in K-8 schools.

A review of the literature led us to approach this task from a dual perspective that respects the context-specific focus of the existing literature but also problematizes this focus by arguing that we need to understand these activities across contexts. Specifically, the term "informal learning" has been used to refer to at least two distinct but overlapping areas of study. Some researchers use the phrase to refer to learning that happens in designed, non-school, public settings like science museums[1] and after-school clubs. Others use the phrase informal learning to focus attention on the largely emergent occasions of learning that occur in homes, on playgrounds, among peers, and in other situations where a designed and planned educational agenda is not authoritatively sustained over time. In this paper, we use the terms 'informal learning' and 'informal learning environments' to refer to experiences within designed settings such as museums. The paper focuses on learning in these designed, informal learning environments. We find it difficult, however, to discuss learning in museums without some reference to

[1] The term "science museum" is used here broadly to refer to science and nature centers, zoos, aquaria, botanic gardens, arboretums, planetariums, natural history and science museums, as well as science-rich children's museums.

emergent learning situations, so distinguish this by using the term 'emergent' or 'everyday' learning.

The first part of the paper provides an overview of the ongoing debate about the use of the term 'informal learning,' and the research that has built up around that term. The second part of the paper examines the kinds of activities engendered by informal learning environments, organized around three common themes in the literature: 1) discipline-specific knowledge, 2) talk as a medium for learning and experiencing science, and 3) identity development. The final section discusses possible directions for the design of out of school learning contexts that can positively impact the development of science knowledge, talk, and identity.

Exploring the Field of Informal Science Learning Research

A distinguishing feature of children's learning is that it often occurs in settings outside of school, focused on interactions with related adults rather than teachers. It has been argued, then, that science education cannot be based in school alone, but must also include the full range of learning environments, including home, museums, and community organizations (Schauble, Beane, Coates, Martin, & Sterling, 1996). Understanding children's science education through a comprehensive effort that integrates the full range of learning environments has a great potential to increase the pervasiveness and improve the quality of children's overall science learning experiences (Martin, 1996).

There are three common arguments for the existence and importance of informal science learning: (1) theory of human development (Schauble, Beane, Coates, Martin, & Sterling, 1996), (2) alternative avenues to success (McLaughlin, Irby, & Langman, 2001), and (3) time out-of-school (Sosniack, 2001). First, informal learning is considered to be the 'third leg' of human development that completes the educative triad of learning within the pre-school family environment and learning in school (Schauble, Beane, Coates, Martin, & Sterling, 1996). From this perspective, examinations of informal, designed, learning environments may both enrich our understanding of learning across environments and force a re-examination of the design of typical formal learning environments.

Second, some children who do poorly in formal educational environments may learn more effectively in informal contexts (e.g., McLaughlin et al., 2001). A combination of factors, including social arrangements, peer networks or mentors, and increases in motivation and interactivity appear to account for this contrast.

Third is time, perhaps the most compelling argument for the importance of informal learning environments. By the age of eighteen, a child will have spent, at most, nine percent of his or her lifetime in school (U.S. Department of Education, 2000). This conclusion is comparable to estimates made more than three decades earlier (Jackson,

1968). Jackson's argument is that if a child spends about six hours a day in school, and is present for each of the one hundred and eighty days required by most states, he will spend little over one thousand hours in school in a year. This is a low estimate of the time spent on schooling activities, as it does not consider time spent on homework. But it is a generous estimate as it assumes perfect attendance, and counts all of the time spent in school as a schooling activity, including activities such as lunch and recess.

Eight to nine percent of a childhood is a great deal of time for one single activity such as schooling. But from the perspective of examining all opportunities for learning, it must be understood as a weak intervention or low dose (Sosniak, 2001). It is, upon reflection, commendable that schools have such an impact after only taking up eight to nine percent of childhood. It is worth adding that in a life of seventy-five years, barely two percent of a person's time will have been spent in schooling. Other educational influences, such as home, community, media, and society must be considered in a complete survey of a person's learning experiences. Herein lies the importance of learning outside of school.

What are the learning possibilities of time-out-of-school? Examining the informal learning experiences of an eighteen-year-old requires the consideration of ninety one to ninety two percent of his or her time. Granted, the activities of playing and critical self-maintenance (e.g., sleeping, eating, and washing) take up a significant amount of time. But we are still left with an extensive educational infrastructure that includes non-school institutions (e.g., libraries and museums), organizations (e.g., community, church and

scouting groups), and media (e.g., books, newspapers, magazines, television, film, radio, and the Web) (St. John & Perry, 1996). Although the existence of this infrastructure is contested (e.g., Luke, Camp, Dierking, & Pearce, 2001), significant evidence suggests that at the least, the groundwork has been laid for a series of connections across institutions, organizations, and communities that allows interaction, communication, and progress (Falk, Brooks, & Amin, 2001; Lewenstein, 2001; St. John & Perry, 1996). Although the definition and extent of the learning infrastructure is contested, it is more readily agreed that the functions of the infrastructure resources for learning outside of school and for connecting to school-based learning are not well understood.

Defining Informal Learning

Efforts to define out-of-school learning have frequently resulted in lists of characteristics that compare informal and formal learning, for example: mandatory versus voluntary (Crane, 1994); de-contextualized versus embedded (Greenfield & Lave, 1982); and, individual versus shared cognition (Resnick, 1987). One of the most distinguishing characteristics to come to light from these lists is structure. In-school learning is described as mandatory, dictated by formal curriculum at local, state, and national levels, as part of a highly organized system of activity. Informal or out-of-school learning is described as voluntary, lacking curriculum and standards, and open-ended. These descriptions are based more on a traditional view of schools and museums than a research-based description of learning environments. Ironically, research on the design of

museum exhibitions[2] (e.g., Vallance, 1995) and on the activities of children participating in day-to-day learning activities (e.g., Henze, 1992) points to a "hidden curriculum" that intentionally or unintentionally structures informal learning environments.

Scribner and Cole (1973) argue that the distinction between formal and informal education is marked by whether it is organized systematically. Specifically, education is formal if it is culturally organized. For example, an apprenticeship, with its specific stages and roles is a formal educational experience. Likewise, ritualistic coming of age ceremonies are formal educational experiences. Even some elements of day-to-day activities have been shown to be a ritualized (Henze, 1992), and therefore could be considered a formal educational experience. It would be difficult, then, to argue that learning from museums is not, at least in part, a formal educational activity.

Development of Research on Informal Learning

The origins of the field of research on informal learning are diverse. Distinctions between formal, informal, and nonformal were first developed in the 1950s (see review in Henze, 1992). The terms were borrowed in the 1970s by museum professionals and environmental educators in an effort to distinguish their activities from schools (Falk & Dierking, 1998). Although studies of informal learning have at times been positioned to be critical of the traditional school learning environment, the outcome has been an understanding of the school as a context with its own culture, history, politics, and

[2] In this paper, the term "exhibition' is used to refer a related set of exhibits. The term 'exhibit' refers to an individual component of an exhibition or a stand-alone piece.

agendas (Bransford, et. al, in press). The use of the term informal learning has flourished in both cultural psychology studies of everyday learning (e.g., Cole, 1996; Scribner, 1984) and educational studies of the museum learning experience (e.g., Hein, 1998). (See Bransford, et.al., in press, for a review of the development of research on everyday learning experiences.)

In the 1980s, a few researchers began to argue that it might be more appropriate to describe informal learning in designed environments as free-choice learning (Dierking, 1987; Koran, Longino, & Shafer, 1983). The intention was to introduce clarity about the nature of the learning, rather than over generalize about the wide variety of learning experiences that take place within a single learning environment such as a museum or even a school. Free-choice learning is voluntary and self-placed. Although it is most commonly used to describe learning outside of school, it is specific to the learning, not the environment, and therefore could be used to describe learning experiences within schools also.

A common concern among those who use the term informal learning and the term free choice learning is the belief that it is important to examine learning over time and across environments (Dierking et. al., 2003). Experiences in schools, museums and after-school clubs, watching television and films, listening to the radio or audio recordings, playing games, reading books, magazines, newspapers, blogs, and other Web resources, participating in community or religion-based organizations, and talking to colleagues,

friends, family, and strangers all cumulatively contribute over time to an individual's learning experience. Historically, what we know about this sort of learning is limited to studies within museums (e.g., Falk & Dierking, 2000) and research on everyday learning from an anthropological or cultural psychology perspective (e.g., Rogoff & Lave, 1984). An interesting middle ground between the two is the highly designed media of television and the Web that is viewed or used within highly unconstrained environments such as the home. There is less published data about the impact of these media experiences, but evidence suggests that access to technology outside of home provides students, particularly boys, with a head start in schooling (see review in Kafi, Fishman, Bruckman, Rockman, 2002). Learning media such as television is even less understood in relation to overall impact on school success. Despite extensive studies on the impact of specific episodes of television shows, most cross-program studies focus on attitudes more so than learning (e.g., Potts & Martines, 1994). Increasingly, there is an interest in examining learning across types of media and mediation, beyond constrained learning environments, and extended through time. The result would be a more holistic understanding of the learning process that measures a scale and scope not yet attempted.

What We Know About Informal Learning

This overview of research on informal science learning environments was designed with an eye toward highlighting findings that can inform K-8 schooling. The number of studies of informal learning pale in comparison to the number of studies of formal

learning. But a range of insights and principles nonetheless distinguish informal learning research and suggest important links to the K-8 school environment.

Psychologists have typically viewed learning changes in terms of concepts or mental processes. Informal learning researchers have described other, though not necessarily incompatible, dimensions of change when people learn. Research on informal and everyday science education has described learning in terms of changing participation and activity within a community (Lave, 1988). This understanding of learning points to the importance of not only concepts or disciplinary knowledge, but also science talk, and identity.

Some researchers have emphasized the importance of developing disciplinary-specific knowledge, such as the big ideas and processes of science (Ash, 2003; Crowley & Jacobs, 2002; Tunnicliffe, 2000). Other researchers have described informal science learning as an opportunity to appropriate the language of science (Borun, et al., 1998; Crowley & Callanan, 1998; Ellenbogen, 2003) Still others have highlighted that learning involves changes in identities, specifically how people view themselves, how they present themselves, and how others see them (Holland, Lachicotte, Skinner, & Cain, 1998; Wenger, 1999). No single definition of learning unites informal learning research. However these three characteristics—disciplinary knowledge, science talk, and identity provide a multi-faceted view of learning that (a) accommodates the need for a nuanced definition of learning; (b) highlights characteristics of learning that are strongly supported

by informal learning environments; and (c) draws upon an understanding of science as a human endeavor (Kuhn, 1970; Latour, 1987; Longino, 1990). Although the three concepts of disciplinary knowledge, science talk, and identity overlap in powerful and productive ways, we describe each concept in turn here.

Discipline-Specific Knowledge

Individuals do make discipline-specific cognitive gains as a result of their museum visits (Allen, 1997; Anderson, Lucas, & Ginns, 20037; Falk & Dierking, 1997; Stevens & Hall, 1997). Studies of cognitive learning in museums have included unguided visits as well as structured programs or tours, but they are all concerned with the disciplinary knowledge gained from a particular exhibition or program.

Much of the work on the development of discipline-specific knowledge in informal learning environments relates to field trips. Numerous studies show that field trips to museums have a positive impact on cognitive gains when students are well prepared with the curriculum, when they participate actively during the trip, and when the field trip experience is reinforced following the visit (Bitgood, 1993; Koran, Lehman, Shafer, and Koran, 1983; Orion, 1993; Ramey-Gassert et al., 1994; Rennie and McClafferty, 1995). Recent reviews of the literature (Anderson, Kisiel, & Storksdieck, in press; Griffin, 2004) describe a series of critical factors that influence the cognitive impact of a field trip, including students' preexisting knowledge, pre- and post-visit activities, orientation to the learning, environment, teachers' perceptions about curriculum fit, and obstacles to field

trip planning. Two of these—teachers' perceptions about curriculum fit and pre- and post-visit activities—emerge as the most frequently cited factors to impact the development of disciplinary specific knowledge from field trips.

Teachers' perceptions of informal science learning environments profoundly influence the kind of visit their students' experience. Perceptions about the rationale for field trips vary widely. A study by Jamison (1998) considered the perceptions of elementary and middle school teachers regarding field-trips a history center and a science museum. The investigation revealed that the location, the quality of the exhibits and programs, the safety and security of students, and relevance of the field trip experiences to the school curriculum were all key factors in teachers planning visits to these sites.

A recent study (Kisiel, 2005), however, demonstrated the dominance of the curriculum fit in teachers' perceptions of field trips. Fully 90% of participating teachers stated that a connection to the curriculum was an important rationale for a field trip. Teachers gain legitimacy for their field trip by showing that it fits the curriculum. The importance of curriculum fit is not surprising, given the increased emphasis on standards and accountability. Although there is much evidence to suggest that teachers justify field trip experiences in terms of curriculum fit in an effort to secure the legitimacy and administrative approval needed to conduct a field trip, there is little evidence that teachers actually integrate the field trip experiences into their curriculum. Anderson, Kisiel, & Storksdieck (in press) found that despite the perceived importance of connecting the field

trip to the curriculum, it is less influential within the reality of planning and conducting the actual excursion. Their data suggest that making a connection to the curriculum, while a desirable outcome, is difficult due to the constraints of the school system. This does not pose a problem to teachers whose perceptions of field trips include a range of rationales and multiple outcomes unrelated to the curriculum, as long as they can prove that the field trip is designed to fit the curriculum.

Several studies have shown that pre- and post-visit activities support students' orientation, understanding, and the development of a context for future experiences (Anderson, Lucas, Ginns, Dierking, 2000; Falk and Dierking, 2000; Gennaro, 1981; Orion and Hofstein, 1994; Storksdieck and Falk, 2003). Anderson (1999) found that post-visit activities were significant catalysts for later development of knowledge in and beyond the classroom and museum settings. Gennaro (1981) reported that a treatment group who participated in pre-visit activities showed greater overall knowledge acquisition from a field trip than a control group that went on the trip without the pre-visit instruction. Orion and Hofstein (1994) noted that students who participated in a 10-hour preparation unit designed to support both orientation to the site and conceptual development prior to a geology field trip outperformed the control group who received no preparation other than completion of a traditional school unit on geology. Storksdieck and Falk (2003) have found evidence that pre- and post-visit activities support not only the field trip itself, but also subsequent learning experiences that provide evidence for the long-term impact of a science museum visit.