ARTICLE IN PRESS
APPDEV-00580; No. of pages: 3; 4C:
Journal of Applied Developmental Psychology xxx (2010) xxx–xxx
Contents lists available at ScienceDirect
Journal of Applied Developmental Psychology

Book review

Training the preschool scientist-in-waiting

Rochel Gelman, Kimberly Brenneman, Gay Macdonald, Moisés Román, Preschool pathways to science: Facilitating scientific ways of thinking, talking, doing, and understanding. Paul H. Brookes Publishing Company, Baltimore, MD, 2010, ISBN-13: 978-1-59857-044-1 (paper), 144 pp, $29.95

Introduction

Recently, *Education Week* highlighted the growing national interest in preschool science education (Viadero, 2010, January 20). The story leaves the impression that educating preschoolers in science is poised to become a national movement. Science education for preschoolers is supported in policy by a recent National Research Council (2007) report advocating preschool science instruction, backed economically by National Science Foundation and Department of Education funds for creating programs and outcome assessments, and guided intellectually by new theoretical insights about the nature of knowledge and young children's ability to acquire it. As early childhood programs are more and more being seen as vital to general social and educational reform, early science education is a potential key component.

But are science education programs for preschoolers a good thing for the children and for science education in general? We ask this question as interested parties with backgrounds in the development of scientific reasoning as a developmental psychologist (EA) and in scientific understanding as a physicist and science educator (AJ). Our question is posed with specific reference to this new book by Gelman, Brenneman, Macdonald, and Román. The book offers a good springboard for the discussion as it presents a preschool science curriculum which (a) conforms to the kind of science education reform advocated by the NRC, (b) is supported by NSF and DOE funding, and (c) was developed by a team led by Rochel Gelman, a leading researcher and theorist in articulating the new theoretical view of the child on which the curriculum is based. The curriculum presented in the book has entered the broader culture as the teaching approach behind *Sid the Science Kid* (http://pbskids.org/sid/index.html), a popular PBS children's show co-produced by the Jim Henson Company.

In a nutshell, the Preschool Pathways to Science (PrePS) curriculum holds that children have a good deal of general knowledge of specific intellectual domains but limited detailed knowledge of those domains. For example, although they readily distinguish between animate and inanimate objects, they may not understand what distinguishes them inside and out. Children's knowledge is leveraged by a PrePS teacher who guides the children through a socially based scientific inquiry process that fills out their domain knowledge and promotes skills relevant to the "scientist-in-waiting." The term *scientist-in-waiting* expresses the recognition that preschoolers are not engaging in authentic scientific activities but are learning how their everyday activities of measuring, predicting, explaining, and similar actions all connect to scientific practices and attitudes in a socially based inquiry process.

The book presents a teacher-level explanation and justification of the PrePS curriculum with an eye to its application. It covers key theoretical issues in the first two chapters, lays out the nature and implementation of the curriculum in the subsequent two chapters, and presents an outcome assessment in the final chapter. The presentation throughout the book highlights how forms of scientist-in-waiting activities connect to knowledge acquisition in particular domains, giving those activities meaning as a process of knowing about the world.

We consider three general questions about the curriculum and, in exploring the answers, present our evaluation of the curriculum and its implications. The first question is whether there is broad evidence of value of the program—whether the PrePS curriculum is a wise and effective use of valuable instructional time. The second question addresses the nature of student outcomes of the curriculum and evidence of the program's success in reaching them. Finally, we consider the broader implications of the curriculum for science education in general.

Is a preschool science curriculum an effective use of instructional time?

Nicolopoulou (2010) recently sounded what is coming to be a commonly heard alarm about the disappearance of play from early childhood education. She notes that the "emphasis on more didactic, academic, and content-based approaches to preschool education comes at the expense of more child-centered, play-oriented, and constructivist approaches which are dismissed as obsolete or simply crowded out" (p. 3). Are preschoolers better off physically, cognitively, and socially if merely given free time to play with each other than if they are included in the PrePS curriculum?

The PrePS curriculum appears to pass the "play test" in that it is designed to engage children's intrinsic interests, to allow for children to direct their own inquiries, to support broad-based cognitive and linguistic skills, and to promote social coordination, which are many of the features deemed important about the role of free play in the early childhood curriculum (Nicolopoulou, 2010). The curriculum is not a pushed-down version of physics, chemistry, or biology with prepared seatwork and a set of facts to remember. Rather, the curriculum builds on children's natural curiosities about the world, but does so by a teacher guiding children's spontaneous science-oriented activities, tool use, and language in socially coordinated ways to promote questions and discussions that lead to insights and conclusions. For example, the authors describe a teacher orchestrating for children a series of socially, mathematically, and linguistically

doi:10.1016/j.appdev.2010.07.007

based activities on the concept of "outsides," focusing on nutshells and skin. The activities were comprised of sorting, weighing, and measuring features of nutshells to draw comparisons, making and recording observations about skin to identify its features, and discussing all the features to figure out similarities and differences between skin and nutshells. Finally, the children were helped to create a collective Venn diagram of their analyses, which the authors note, "was successful because teachers allowed children to explore both objects, make observations, and build on familiar scientific practice (recording observations) to introduce this new kind of representation" (p. 77).

Although passing the free play test may be the first hurdle, the adequacy of the design of the PrePS curriculum may also be assessed by comparing it to other preschool curricula. PrePS conforms to principles of other early childhood programs, among them the Project Approach (Katz & Chard, 1989), Montessori (Lillard & Else-Quest, 2006), and Reggio Emilia (Edwards, Gandini, & Forman, 1998), which are based broadly on the constructivist notion of children as active learners. However, the PrePS focus on the child as a scientist-in-waiting who learns the forms of practices, tools, and language of a socially based scientific inquiry process is different from other constructivist early childhood science curricula. For example, Chaille and Britain (1997) created a science curriculum based on drawing a direct analogy between children and scientists as theory builders. Their curriculum is designed to support children's scientifically authentic theory building activities, with teachers serving as facilitators to promote their engagement in developmentally appropriate ways. As they put it (p. 18):

> Real science incorporates many things to which young children are particularly open: creative thinking and problem solving and experimentation and invention. Many of the processes that the practicing scientists use are seen in microcosm, in the way that young children construct knowledge.

With its focus on theory building, the Child-as-Scientist model suggested by Chaille and Britain more strongly encourages children's reasoning about and understanding of particular phenomena (e.g., marble rollways) than the more general processes of science itself. This tension between promoting children's understanding of particular phenomena and general processes of science is in more equal balance in the Scientist-in-Waiting model of PrePS, with its focus on children's learning about the practices, tools, and language of a socially based scientific inquiry process. In essence, PrePS prepares children with scientific habits of mind to provide an implicit foundation for future scientific endeavors, rather than emphasizing specific theory-building activities.

Are there valuable student learning outcomes from PrePS?

Gelman et al.'s (2010) final assessment chapter is important in order to understand the potential value of the PrePS approach. As implied above, they propose broad-based outcomes in terms of children's abilities to "talk, think, and work scientifically" (p. 103). The curriculum and its outcomes are based on the domain-specific approach to studying cognitive development (Gelman & Lucariello, 2002), which assumes that children have preexisting abstract cognitive structures of particular domains of knowledge that support their search for and understanding of relevant information which in turn fills out the structure. The preexisting structures support children's scientific reasoning in specific content domains including the mind, biology, and physics and their understanding of scientific practices, including abilities to count and measure, to experiment and effect change, and to organize and sort. These preexisting structures are used to hone children's scientist-in-waiting skills and dispositions and to promote their understanding of the social nature of the inquiry process.

Although assessment research of the PrePS outcomes is limited for this new program, the data are encouraging. The quality of the PrePS classroom appears to effectively support children's learning. Scientific practices, specifically experimentation skills, are stronger among those who had experienced the PrePS curriculum than those who did not and stronger among children after experiencing the PrePS curriculum than before. Finally, specific content knowledge about the senses, growth, and life cycles was also found to increase due to the PrePS program.

Despite this success, we wonder whether the outcome value of the PrePS program lies as much, if not more, in the development of knowledge about and positive attitudes towards socially based inquiry than in the development of scientific content knowledge and inquiry skills, as important as they are. That is, beyond the growth of scientific knowledge and practices that are supported by PrePS, we think assessments should be made of the impact of PrePS on children's understanding of and positive attitudes towards the inquiry process itself, both short and long term. For example, although the authors encourage teachers to collect data about curriculum-inspired discussions and interactions among children as these are considered important for the socially based inquiry process, there is no assessment of children's own recognition of the value of discussions and interactions in knowledge acquisition. Similarly, teachers are encouraged to promote journal recording as a way to support children's learning and memory and as an assessment tool. Assessments were made of children's development of journaling skills and its use for documenting and measuring change, but not their understanding of the role it plays in the inquiry process.

We think that the development of knowledge and positive attitudes towards the inquiry processes itself is a critical but untapped outcome of the PrePS program. Fostering a positive orientation to scientific inquiry seems to be an important step to reach the National Research Council (2007) goals of promoting an understanding the nature and development of scientific knowledge, including active participation in scientific collaboration and discussion. It may also be the longest lasting student outcome of the PrePS program as students likely do not experience a guided scientific inquiry experience again until college. (Whether PrePS programs should suggest and help promote similar reforms in later grades is an interesting question to us, as is the potential for later grades and experiences to "squash" scientific attitudes that might have been fostered in the PrePS program).

The assessment research can probe whether children recognize the importance of and adopt a positive attitude towards discussions and interactions as part of the process of gaining knowledge. Similarly, research can also address whether children conceptually grasp and value how measuring and recording phenomena is tied to how they come to learn about reality. We do not mean these research projects to be deep epistemological studies of young children, but rather ones that tap their intuitive sense of the relevance and significance of the activities. It is exciting, nonetheless, to imagine possibilities in later years for these children as they could continue to expand upon the inquiry processes they gain experience with at such an early age.

Are there broader implications for science education in general?

The physicist Otto Robert Frisch (1979, p. 86) noted that "scientists have one thing in common with children: curiosity. To be a good scientist you must have kept this trait of childhood, and perhaps it is not easy to retain just one trait." It is ironic then that we are reaching into the preschool, seeking to encourage more scientists and scientifically literate citizens. But the PrePS curriculum is designed to direct children's natural curiosity into an opportunity for them, as scientists-in-waiting, to learn about scientific practices, tools, and language which connect to a socially based inquiry process. We think

this is an important foundation for children in the goal of making the process of science accessible to and understood by all.

We were struck by the characterization of the preschooler as a scientist-in-waiting and used the expression to think about the differences between college students engaged in undergraduate research with a faculty member as opposed to merely working in the faculty member's laboratory, even to run their own project (Johnston & Amsel, 2010). In addition to acquiring skills for running a research project in a lab, students engaged in faculty-supervised undergraduate research are (hopefully) learning how their activities are connected to the epistemological foundation of science and the process by which it changes. Although there is a substantial distance between the preschool child and the undergraduate researcher, each is a scientist-in-waiting as both are being guided to discover how their activities connect to the broader nature of science. But more needs to be done from preschool to college to help scientists-in-waiting to understand the connection between scientific practices learned in school and the nature of science. The challenges are substantial at each level to promote the skills of those guiding the scientists-in-waiting as they must have knowledge not only of scientific content and practice, but also of how the two are related to the process and institution of science.

In summary, there is much to like in Gelman et al.'s (2010) PrePS curriculum. We see in the PrePS a new look to preschool science education that can promote reasoning and understanding not only regarding scientific content and practices but also regarding the process of scientific inquiry. We think that the latter goal is particularly innovative and encourage the team to add it to their short-term and long-term assessment goals. Moreover, we think that such a goal of a science curriculum is needed not just in preschool, but at each level of education to promote in all scientists-in-waiting a better understanding of science as a process and institution. Researchers and policy makers alike would be wise to consider these goals for the citizens we are educating in our technologically and scientifically complex society.

References

Chaille, C., & Britain, L. (1997). *The young child as scientist: A constructivist approach to early childhood science education*, 2nd Ed. New York: Longman.

Edwards, C., Gandini, L., & Forman, G. (1998). *The hundred languages of children: The Reggio Emilia approach—Advanced reflections (2nd Ed.). Greenwich, CT: Ablex.*

Frisch, R. O. (1979). *What little I remember*. Cambridge, UK: Cambridge University Press.

Gelman, R., & Lucariello, J. (2002). Learning in cognitive development. In H. Prachler, & C. R. Gallistel (Eds.), , 3rd Ed. *Steven's handbook of experimental psychology*, *Vol. 3*. (pp. 395—443)New York: John Wiley and Sons.

Johnston, A., & Amsel, E. (2010, June). Students' understanding of the scientific process: Transformation or stagnation. *Paper presented at the Council of Undergraduate Research meeting, Ogden UT*.

Katz, L. G., & Chard, S. C. (1989). *Engaging children's minds: The project approach.* Norwood, NJ: Ablex.

Lillard, A., & Else-Quest, N. (2006). Evaluating Montessori education. *Science*, *313*, 1893—1894.

National Research Council (2007). Taking science to school: Learning and teaching science in grades K-8. Committee on Science Learning, kindergarten through eighth grade. In Richard A. Duschl, Heidi A. Schweingruber, & Andrew W. Shouse (Eds.), *Board on Science Education, Center for Education. Division of Behavioral and Social Sciences and Education*. Washington, DC: The National Academies Press.

Nicolopoulou, A. (2010). The alarming disappearance of play for early childhood education. *Human Development*, *53*, 1—4.

Viadero, D. (2010, January 20). Researchers testing programs to teach science to preschoolers. *Education Week*, *29*, 10.

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26 July 2010
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