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Brief Report

Social science as a tool in developing scientific thinking skills in underserved, low-achieving urban students

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ABSTRACT

Engagement in purposeful problem solving involving social science content was sufficient to develop a key set of inquiry skills in low-performing middle school students from an academically and economically disadvantaged urban public school population, with this skill transferring to a more traditional written scientific thinking assessment instrument 3 weeks later. Students only observing their peers' activity or not participating at all failed to show these gains. Implications are addressed with regard to the mastery of scientific thinking skills among academically disadvantaged students. Also addressed are the efficacy of problem-based learning and the limits of observational learning.

Introduction

Originating with the classic work by Inhelder and Piaget (1958), research on the development of scientific thinking has a now long history in developmental psychology (for reviews, see Kuhn, 2011; Lehrer & Schauble, 2015; Moshman, 2011; Zimmerman, 2007), mostly devoted to the "control of variables" (COV) strategy, although COV is no more than one aspect of authentic scientific practice (Kuhn & Arvidsson, 2015; Lehrer & Schauble, 2015). The educational relevance of this line of work is considerable. The COV strategy appears in the Next Generation Science Standards. (2013) from the middle grades through high school as a key understanding that all students should achieve.

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Argumentation also now figures prominently in the standards, with valid (nonconfounded) comparisons being a key building block of sound scientific arguments (Ford, 2012; Kuhn, 2010).

We focused here on a low-SES (socioeconomic status), low-achieving middle school population, a population for which it is difficult to develop rudimentary scientific thinking skills, compared with success in doing so among more privileged students, according to researchers (Kuhn & Dean, 2008; Lorch et al., 2010; Siler, Klahr, Magaro, Willows, & Mowery, 2010). Among multiple challenges that these low-achieving students face, a formidable one may be their inability to recognize the point and purpose of scientific practices. The approach we introduce here is novel in its use of social science as a potential "hook" in engaging students in science as a practice and enabling them to appreciate its purpose and power (Lehrer & Schauble, 2015). Such topics are ones that students know something about. But they likely will not know that they are the stuff of science. What better way, then, to get them to see its power and relevance?

The method we employ has the further appeal of involving an authentic problem to be solved. The process, often called inquiry learning, is largely self-directed and exploratory (what will be learned is not known in advance) and encompasses investigation, inference, and argumentation (Duschl, 2008). Each of these entails further specific skills (Kuhn, 2011, in press; Zimmerman, 2007), and these must be coordinated in the common case in which multiple variables affect an outcome (Kuhn, Ramsey, & Arvidsson, 2015). We focused here on a foundational skill central to effective inquiry—generation of informative evidence. In the most common multivariable context, it requires selecting for comparison instances equated on all known other variables, allowing a valid inference regarding the effect of a focal variable. In the absence of this control of variables strategy, faulty inferences are likely (typically when outcome differences are attributed to an uncontrolled variable rather than their true cause).

Our intervention method fulfills criteria for problem-based learning (PBL) as well as inquiry learning. Studies of PBL largely address declarative knowledge acquisition (Hmelo-Silver, 2004). We asked here whether PBL is effective in developing procedural skills that enable and support declarative knowledge acquisition. Thus, we asked students to acquire not specific content knowledge ("right answers" to the problems posed) but rather effective procedures for obtaining answers. The problem remains ill-structured; no direct instruction is given as to how to address it. The instructional method is guided inquiry; a coach remains present and makes comments and suggestions without, however, explicitly directing students' activity. We followed the PBL model in designing a problem that students would find realistic and engaging, an important characteristic for low-performing students who typically exhibit low levels of engagement in school settings, and we afforded them ample time to engage deeply with the problem.

Thus, we asked here whether social science content, in conjunction with a PBL instructional method, can help to develop key scientific inquiry skills among a low-achieving population unlikely to master such skills without extended intervention (Kuhn & Dean, 2008; Siler et al., 2010), in contrast to more advantaged students. Following Pease and Kuhn (2011) and Wirkala and Kuhn (2011), we compared individual and group conditions, allowing us to establish whether the characteristic PBL small-group format is essential to the method's effectiveness. Finally, to this comparison we added a third instructional condition, one in which learning occurs only vicariously, to determine whether the active dimension is essential—an important question when addressing procedural knowledge.

Method

Participants

Participants were 79 sixth- and seventh-grade students (38 girls) attending an urban public school. Most (73%) were African American, and nearly all of the remainder were Latino. More than 65% qualified for free or reduced-price lunch. The large majority functioned below grade level. In standardized assessments, 6.5% of students at the school were classified as proficient (Level 3) in English language arts (ELA) and 4.9% in math.

All 117 students in sixth and seventh grades took a written pretest that assessed mastery of the COV skill. The 88 selected to participate were those whose scores indicated no mastery of the COV skill. Of these, 9 did not complete the intervention and were excluded.

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