Systematic Review of Outdoor Science Learning Activities with the Integration of Mobile Devices

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ABSTRACT

The purpose of this systematic study review was to describe how researchers integrated mobile devices into outdoor science learning, assessment of those activities, and alignment of purpose, integration, and assessment. From initial 980 search results, the authors selected 45 articles based on the eligibility criteria of: (a) empirical study; (b) learning activity with science content; (c) outdoor setting; (d) mobile device integration; and (e) assessment. Researchers designed outdoor science learning activities integrated with mobile devices for the purposes of science knowledge gain, affective domain gain, and scientific inquiry. Researchers aligned components of scientific inquiry including hypothesis formation, observation, data collection and interpretation, and communication and collaboration. Conclusions describe benefits to integrating mobile devices with outdoor science learning activities by supporting scientific inquiry skill development. Alignment of purpose and assessment provides evidence of student learning important in meeting accountability standards.

KEYWORDS
Accountability, Designers, Educators, Formal, Informal, Literature Review, Purpose, Technologists, Technology

INTRODUCTION

Many students of all ages look forward to going outside to investigate the natural world. Outdoor educational settings may heighten the senses, thereby helping students develop observation skills (Chinn & Malhotra, 2002). Science educators may engage students and facilitate cognitive knowledge in an outdoor setting by using scientific inquiry, a process of observing natural phenomena, forming explanations, gathering and interpreting data, and communicating findings with others (Martin-Hansen, 2002). To enhance the experience, mobile devices may be integrated with outdoor science learning activities as a tool for supporting and scaffolding learning (Crompton, Burke, Gregory, & Gräbe, 2016). The relationship among these issues is under-explored but is increasingly important in designing meaningful learning for students of all ages.

BACKGROUND

Designing meaningful learning experiences and measuring the impact of that learning is important to many stakeholders including education administrators, and school funding may be impacted by student performance (Ravitch, 2016). Increasingly, science educators at all levels of education experience an

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external push to design instruction towards accountability and addressing science standards (Chesky & Wolfmeyer, 2015). In the US, for example, Next Generation Science Standards guide learning outcomes for science domain learning for K-12 (ages 5-18 years) students (NGSS Lead States, 2013). Scientific inquiry, integrated with engineering design practices, serves as one NGSS dimension of the standards, along with the dimensions of cross-cutting concepts and disciplinary core ideas (NGSS Lead States, 2013). These three dimensions ideally are covered in all age and grade bands and provide a basis for postsecondary science educators to accumulate prior knowledge. There is flexibility, however, regarding how science educators implement and assess NGSS, leading researchers to recommend, “Thus, at the school and classroom level, research is needed to examine rigorously how standards are interpreted” (Fulmer, Tanas, & Weiss, 2018, p. 1095). The authors of this systematic review partially address this recommendation by examining how science educators implement an aspect of science education that some consider innovative. The authors conceptualize this innovation as science learning activities, with integration of mobile devices, in formal and informal outdoor settings for students of all ages, and aim to provide a global perspective of this issue. Although standards are not the same in many countries nor uniformly implemented at a collegiate level, all science educators should design and integrate science learning activities with intention and assess whether that intention was fulfilled. Thus, standards such as NGSS were used as a broad conceptual framework for the systematic review but were not used as a measure of attainment by each study.

The concept of alignment deserves mention, as it played a key role in this systematic review. Alignment is a term that, like scientific inquiry, has different meanings depending on context. In a broad sense, alignment is the degree of similarity in aspects of curricula, programs, or educational standards (Webb, 1997). In this study, the authors define alignment as how closely intentions or purpose for an outdoor science learning activity match the assessment. Other researchers show how science educators’ intentions followed through in their assessments (Sandlin, Harshman, & Yezerski, 2015; Webb, 1997). Examining earlier work presents another cloudy concept. Words such as goals, expectations, outcomes, objectives, purpose, and intent may generally encompass what science educators intend to accomplish in terms of student learning (Sandlin et al., 2015; Webb, 1997). In this study, the authors used the words intention and purpose to capture this concept. The authors did not use the terms objectives or outcomes because those terms may have accountability connotations and the authors did not examine documents such as lesson plans in which these terms would have been precisely documented.

**Scientific Inquiry**

How do science educators design activities to educate students? There are two broad areas where students may gain cognitive skills: science knowledge such as key organizing concepts; and scientific process skills such as investigating a problem or question (NRC, 2012). Disciplinary core ideas, along with cross-cutting concepts, are NGSS key organizing concepts. Students gain knowledge in increasing levels of depth and sophistication by instruction over time (NRC, 2012). Students use a logic-based process called scientific inquiry to answer questions. The scientific inquiry process may be combined with engineering design practices to solve a problem. The authors of this study utilized a holistic, global perspective encompassing students of all ages. For this reason, the authors did not evaluate each study according to alignment with standards that may not apply in a particular context. Rather, the authors examined each study to understand how science educators use scientific inquiry and teach science knowledge.

The process of scientific inquiry has an ill-defined meaning, but generally the initial phase begins by forming a guiding question, hypothesis, or problem (Martin-Hansen, 2002; Rönnebeck, Bernholt, & Ropohl, 2016). In the next phase, students conduct observations and collect data and, when feasible to do so, conduct experiments to support or dispute the hypothesis (Martin-Hansen, 2002; Rönnebeck et al, 2016). Students interpret and analyze data to compose logic-based explanations and descriptions of phenomena (AAAS, 1993). The final phase relies on communication and collaboration with group
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