Toward the Design of Scaffolds for In-the-World Situated Science Reflections Through Wearables

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Abstract: This paper presents a study with 38 elementary school-aged children using smartwatches in their everyday lives for reflections on 3 science topics. We analyzed the recordings retrieved to understand what and how children noticed their everyday experience to relate to science. Findings identify the types of noticing 'triggers', common faults in the science reflections, and the nature of the reflections. We discuss how our findings point to recommendations for the design of scaffolds to support situated reflective learning through smartwatches.

Introduction

The need to help students see the relevance or value of science in their everyday lives has long been a goal of both formal and informal education. Curriculum relevant to students' everyday lives may be a way to eventually develop individuals that will form a scientifically literate citizenry, but it is challenging for science teachers to connect formal science concepts taught in the classroom to everyday situations (Cajas, 1998, 1999). We argue that wearable technologies can potentially address the problem of personal relevance in formal science learning by having students reflect on how specific concepts are present in and can be applied to situations and objects that they are familiar with in everyday experience. Our research looks at how wearable devices may be used to enable students to have such situated reflections about science. Through qualitatively analyzing situated reflection recordings made by 38 elementary aged students, we aim to understand what kinds of scaffolds are needed to support students to produce effective science reflections in their day-to-day life.

Theoretical framework

Our research posits that the smartwatch has critical properties that can support out-of-school situated learning, especially in science. Situated learning posits the importance of the "integration of subject-matter knowledge and everyday knowledge…for children's conceptual development" (Hedegaard, 1998). Unlike desktop computers, smartwatches do not require the user to be tethered to a specific location, and when well-designed, may enable situated science reflections. Reflection entails purposeful thinking oriented toward a goal (Dewey, 1997). Moon's 'map of learning' (Moon, 2013) defines five stages of learning that range from the least to the most reflective: Stage 1 – 'taking notice of new information'; Stage 2 – 'Making sense'; Stage 3 – 'Making meaning'; Stage 4 – 'Working with meaning'; Stage 5 – 'Transformative learning'. Using this framework as a starting point, we break down the process of capturing a reflection with a smartwatch as consisting of at least three aspects:

1) Noticing, or being able to identify *what* could potentially relate to science in one's everyday environment – everyday life and everyday environments are noisy, unlike a classroom setting where the focus of attention is deemed to always be on the teacher and on the content to be learned;
2) Determining *how* the identified item interrelate with science – this is dependent upon recollection of the science concept at a specific moment and current level of understanding; and
3) *Deciding* to capture the reflection into the smartwatch – the user must first be motivated to initiate the capture, and second encode the reflection in a format suitable for capture.

Our goal is to understand what kinds of scaffolds need to be designed into a science reflection smartwatch app to support the first two processes. We addressed two research questions: i) What kinds of science reflections do elementary school-aged students capture using smartwatches?; and ii) What kinds of structures are needed to support children's situated reflections through smartwatches?.

Table 1: Summary table

	Friction	Gravity	O^2-CO^2 Cycle
Total no. of recordings	70	19	45
% of recordings that have noticing 'triggers'	77%	79%	71%
Average no. of principles per recording	1.57	1.28	2.90
% of recordings with at least one incorrect principle	41%	32%	48%

Methods and Analysis

We conducted a study in which 38 participants used commercial smartwatches to capture reflections on the science topics of *friction*, *gravity*, and the *oxygen-carbon dioxide cycle* throughout their everyday lives. The study was done in two phases: i) 20 children (12 boys and 8 girls) aged 8 to 11 were invited to a lab to use the Samsung Gear Neo 2; and

ii) 18 children (7 boys and 11 girls) aged 10 to 11 from a local elementary school science class used the ASUS Zenwatach 2. Both watches allowed for 48 hours of continuous use and voice recordings. Students were told to do recordings of whatever they thought could be related to the given science topic in their everyday life over two and half days. A total of 131 recordings were collected and transcribed. The first row of Table 1 shows the total number of recordings for each science topic.

Findings

Table 1 shows the % of recordings motivated by an aspect of the child's observation of the real world; the average number of science principles by topic; and the percentage of recordings with faulty principles by topic. We proposed earlier that situated science reflections involve at least three aspects: noticing science in the world, relating one's observation to science, and being motivated to capture reflections. Our analysis of the reflections led to: 3 categories of noticing science (observation, doing an activity, and engaging in an experiment); 3 categories of inaccuracy of reflections (wrong mental models, lack of knowledge, ambiguity or conflicts). E.g., in the following recording, the child attributed a wrong cause to the science concept: *"The friction of me writing with my pencil since the paper was a solid surface it would not move back."* The 'solidness' of the surface is not the reason why the paper did not slide back; and 4 types of reflection recorded (explanation, reason/cause and effect, use, and question-asking). Each category had sub-categories, shown in Figure 1 with percentages indicating prevalence.

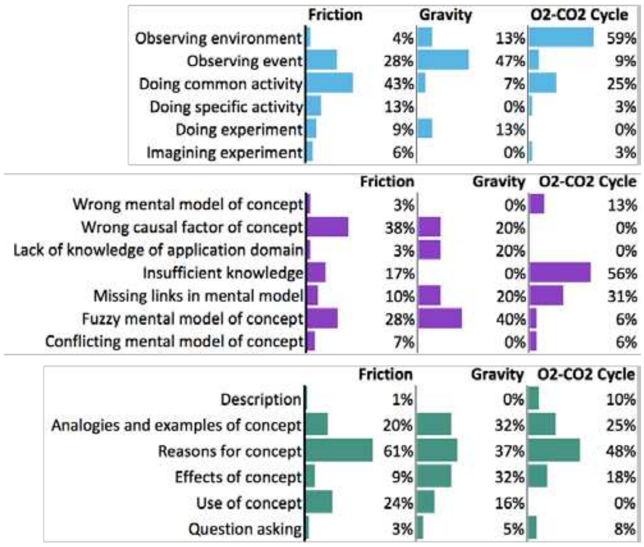

Figure 1. Types of noticing 'triggers' (top' Types of inaccuracies (middle); Types of application (bottom).

Discussion and conclusion

This study showed that the approach of situated reflection through the smartwatch allows for the integration of science learning and personal relevance, whereas working through a set of application questions in class is far less powerful. Recordings were heavily skewed toward observing one's surroundings for the topic of $O^2 – CO^2$ cycle. For gravity, the emphasis was on observing a specific event, and for friction, reflections happened more while doing an activity. The ease of making situated reflections appears related to the type of content. Friction and gravity are both principles, while $O^2 – CO^2$ cycle is more of a representation. Faulty reflections were caused mostly by gaps in knowledge but over time we expect children to learn more complex models of how the science concepts work. Problems with inaccuracies and lack of clarity in the recordings are more problematic because although the children demonstrated that they can recognize features from an everyday situation and relate them to science concepts, associations made were only general and students failed to retrieve precise factual information about the science concept. Moreover, while the recordings were tremendously rich in terms of application domains, a significant number of reflections tended to be descriptive. We suggest that smartwatch scaffolds are needed to: i) stimulate inquiry-based activities; ii) account for the type of science topic assigned; iii) identify patterns of faults in reflections to request review and recapture; and iv) convey factual information related to the science concept to motivate deeper level reflections.

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