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Investigating Creative Inquiries with Tablet-Cloud Systems in Elementary Science

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Abstract

This paper is discussing first outcomes of an ongoing research (2012-2015) about creative inquiry-based learning with tablet-cloud systems in elementary science education. The study is investigating the situated ways in which 8 to 12 year old students make sense of science phenomena through creative inquiry practices enhanced by tablets and cloud systems.

Inquiry can be defined as an active creation of knowledge through the pursuit of open-ended questions, data gathering and related explanations from evidence.

Inquiry-based school activities constitute a learner-centred context for students to develop understanding of scientific concepts and basic inquiry abilities as for example posing and refining research questions, planning and managing an investigation or analysing and communicating results.

From early childhood onwards, children explore their environments and actively build knowledge through interest-driven inquiry. New media devices may support or even extend this inclination as they offer the potential to extend the domain and range of children's inquiry. Especially, new tablet-computers include an array of features, which allow to capture, collect, treat and visualize a span of multimodal data related to science phenomena under exploration. Applications enable students to merge data from their own investigations with content they retrieve from digital sources. This student-generated content can be easily shared with teachers and other groups through the school-based cloud system or disseminated as final outcomes to a private or public audience.

The paper discusses the potential of tablet-computers to facilitate student-centred exploration of science phenomena and the formation of scientific thinking in school-based science activities. Evidence is based on different kind of data collected either by students on the internal school cloud (multimodal classroom productions, self-recordings about their inquiry approaches) or by researchers (video data from science lessons, video-stimulated recall interviews with students).

Outcomes of our analysis reveal that mobile devices create extended opportunities for skill development in science classrooms. We evidence an increase of self-directed, inquiry-oriented and interest-driven learning skills. The tablet-cloud systems stimulate student engagement and self-expression, i.e., explanations from self-collected evidence, evidence-based argumentation and justification of own approaches.

1. Research focus

The study explores how mobile devices facilitate a student-centred exploration of scientific phenomena and the formation of scientific thinking skills among 8 to 12 year old students. The research is sparked by several research questions. However, in this paper our emphasis is on how tablet-cloud systems facilitate inquiry-based science learning regarding their potential to a) support interactive forms of inquiring and gathering of own data, b) develop digital literacy skills as described in current 21st century learning and teaching frameworks.

2. Methodology

The study is framed by sociocultural, anthropological and interactional theories and investigates technology-mediated learning and knowledge construction phenomena in their systematics of elements-in-mutual-interaction. The focus is both on collective and individual processes of development and change. Therefore, it employs a *multi-method framework* to gain a very complete and valid understanding of the situated processes occurring in classroom activities. It combines five different data sets in a complementary perspective: 1) students' multimodal science productions, 2) students' video comments upon their learning processes (both sets are stored on the cloud), 3) video recordings of ICT-enhanced classroom activities, 4) video recordings of stimulated recall interviews with students, 5) online questionnaires about students' digital literacy background. These data sets are investigated with different analytical tools focussing on multimodal interaction (video data), multimodal content (students' multimedia productions), students' discourse (students' auto-recordings of inquiry processes, teacher comments) and survey data. This triangulation approach creates a multi-perspective view of the processes occurring in the ICT-enhanced learning and teaching practices. The research is also *longitudinal* in nature [15] and follows children, teachers and the school community during a two-year learning cycle.

3. Study details

The research is conducted within four schools, which have been equipped with tablets and basic accessories (WiFi stations, Apple TVs…). Tablets feature an array of sensors, which allow kids to capture, treat, visualize and aggregate multimodal data related to science phenomena under exploration. Applications enable students to merge data from their own inquiries with content they retrieve from digital sources (online, e-books…). Students can share their content within groups or with their teachers through a cloud system that has been integrated into the IT architecture of the project schools. It allows to bridge in-school and out-of-school activities across time. Cloud-based content is accessed via multiple platforms (smartphones, computers…), at the same time and beyond the constraints of physical classroom organization, i.e., in contrast to material resources located in the classroom only. Hence, the cloud technology facilitates a) instant, easy and remote access to students' documents such as texts, pictures or videos; b) collaboration within and across student teams; c) sharing of resources among actors within and beyond the classroom; d) dissemination of final productions to a private or public audience. The project team meets the teachers on a regular basis to co-develop pedagogical practices according to participants' needs, demands, expectancies and experiences.

4. Theoretical framework

Everyday practices are increasingly mediated by handheld devices and interactive technologies - particularly since novel devices such as Apple's i-devices started shaping the communication and media domain. Currently, these popular tools are entering schools as promising means to improve teaching and learning in respect of the 21st century challenges [19]. Evolutions of that kind are not new. Novel technologies have been hyped at all times as potential 'game changers' and tools to initiate much-needed educational reform [12]. However, history informs us that the implementation efforts mostly struggled to achieve the high expectancies [10]. The regular use of ICT technologies in elementary/secondary education is anyway far from common, and rarely goes beyond rudimentary functions or limited applications [09]. On the other hand, extended immersion in technology-enriched and media-suffused home practices – often from an early age on - does not automatically make kids digitally literate [25, 05, 22]. Information accessing skills are mostly highly developed in sharp contrast to critical thinking and evaluation skills [21]. Hence, context-sensitive research is needed to investigate the implications of mobile learning across in-school and out-of-school contexts and the hurdles that have to be overcome [01].

From an ontogenetic perspective, members of a cultural community need to get familiar with the prevalent practices and knowledge artefacts [03]. However, communities have also to stimulate the creative re-configuration of the prominent cultural knowledge tools [24, 06, 07]. For this reason, (science) education has to provide support and opportunities for both aspects and enable upcoming generations to both reproduce and transform the culturally pre-given. As regards the development of (thinking) tools, practices and/or identities [28], we go along with cultural-historical approaches in the legacy of Vygotsky [26]. They state that joint cultural activity [20] generates the context in which people construct and reconstruct their ways of arguing, inquiring, imagining, reasoning, knowing, re-presenting… as an outcome of, and as mediating tools of the specific activity system in play - here, in science education.

Digital literacy frameworks are conceptualised in manifold ways and continuously updated referring to technological, organisational or pedagogical improvements [18, 02, 14]. Currently, holistically inspired approaches combine 21st century student outcomes (specific skills, content knowledge, expertise and literacies) with innovative support systems to "help students master the multi-dimensional abilities required of them in the 21st century and beyond" [23]. The concept of "participatory culture" [17] reflects the enhanced opportunities that media- and technology-enhanced learning approaches provide through novel digital tools, which "make media production and social interaction easier than ever before" [13]. They offer engaging formats for interactivity and self-expression [16] and stimulate students to engage in meaningful learning experiences.

The present research scrutinises technology use that affects students' learning during inquiry-based science activities and collaborative knowledge construction. Inquiry-based science activities constitute a learner-centred context, which promotes the understanding of scientific concepts and the acquisition of basic scientific skills as for example posing and refining research questions, planning and managing an investigation or analysing and communicating results [11].

Already more than twenty years ago Blumenfeld et al. [04] analysed how computing and networking technologies support project-based science learning. The authors identified six contributions: 1) enhancing interest and motivation, 2) providing access to information, 3) allowing active, manipulable representations, 4) structuring the process with tactical and strategic support, 5) diagnosing and correcting errors and 6) managing complexity and aiding production. Wang et al. [27] explain more precisely that technology uptake supports inquiry process of children by a) enriching and structuring problem contexts, b) facilitating the utilization of resources, c) supporting cognitive and metacognitive processes.

5. Scientific relevance

The study is of substantial relevance for conceiving sustainable technology-enhanced learning environments in school contexts. It nurtures advancements in the theoretical, methodological and pedagogical domains and is of major interest for the conference domain of science learning and instruction in todays' socio-digital ecosystems.

Regarding basic and applied research, it is relevant how and to what extent idiosyncratic ways of thinking and acting come into being, are dialogically taken into account by other participants and might be tackled for further improvement through teachers or peers. Interactive technologies allow to track these processes and to give ecologically valid insights into the sociocultural fundaments of students' (science) learning.

Insights in learning practices inform teachers and researchers about pedagogical approaches, strategies, difficulties to overcome in order to launch creative inquiry processes with mobile technologies and cloud learning in science education.

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