Integrating Co-Design Practices into the Development of Mobile Science Collaboratories

Daniel Spikol, Marcelo Milrad, Heidy Maldonado*, Roy Pea*
Center for Learning and Knowledge Technologies (CeLeKT)
School of Mathematics and System Engineering, Växjö University, Sweden
**Stanford Center for Innovations in Learning*
Stanford University, Stanford, California
{daniel.spikol, marcelo.milrad}@vxu.se
heidym@cs.stanford.edu, roypea@stanford.edu}

Abstract

Scientific practices increasingly incorporate sensors for data capture, information visualization for data analysis, and low-cost mobile devices for field-based inquiries incorporating open web standards. While a broad range of design approaches for developing technology-enhanced learning has been used by researchers and practitioners for the last 15 years, significant challenges for educational use remain as new technologies and user experiences continually evolve outside the classroom. We focus on the specific design challenge of how to initiate the co-design process together with teachers, researchers, scientists, designers, and developers in order to devise and develop mobile science collaboratories that support open inquiry-based learning in ecology education. The outcomes presented in this paper point towards the need for additional methods to support co-design that take into consideration future user experiences needed for developing and implementing these types of learning activities.

1. Introduction

Interdisciplinary science learning activities supported by technology have a long history in educational research and practice [2]. Contemporary scientific practices increasingly incorporate sensors for data capture, information visualization for data analysis, and low-cost mobile computers/phones for field-based work. These different devices use the open web standards as part of the toolbox for the experiments. The introduction of these specialized mobile devices and sensors in educational settings allows them to be used beyond generic, portable productivity tools. Thus, these devices open up new possibilities for supporting science education where learners can pervasively collect data as they use interactive tools in authentic situations, access a variety of educational resources, and participate in collaborative learning practices while in the field [6, 17].

Designing and implementing these new kinds of technology-rich learning activities poses many challenges for educational technology researchers and practitioners. One prospect for overcoming these obstacles is to utilize a design research approach. Design research and design experiments are concerned with the design of learning processes, taking account of the involved complexities, multiple levels and contexts of educational settings [8, 18]. Although design approaches for developing technology-enhanced learning have been in widespread use by researchers for last 15 years significant challenges remain as new technologies and user experiences continually evolve outside the classroom. In this paper we present our current efforts related to how to initiate the co-design process together with teachers, researchers, scientists, designers, and developers in order to develop mobile science collaboratories to support open inquiry-based learning.

The next section describes the project in which our efforts are taking place, together with issues related to the co-design process and other design methods. Section three details the activities conducted in the first co-design workshop with teachers, researchers and developers, followed by section four in which the outcomes of the workshop are discussed. The paper concludes with a discussion about these initial results and our future efforts.

2. Background

The activity presented in this paper is part of the initial phase of a 3-year international project. One of the main goals of the LET´S GO (*Learning Ecology with Technologies from Science for Global Outcomes*) project is to develop the notion of "open inquiry" for promoting and sustaining science in the domain of field ecology for K-12 students. Another goal is how to design challenging collaborative learning activities supported by mobile and sensor technologies and wireless internet. In this context, we define the concept of "mobile science collaboratories" as a set of mobile devices, open software tools and resources, and online participation frameworks for learner collaboration and inquiry. A central aspect of the project is to promote young learners (ages 14-17) working in projects that involve mobile media and data capture, analysis, reflection, and publishing in the field of ecology. Our project continues the body of work in inquiry-based science learning with different mobile technologies [see 4, 5, 10, & 11]. We are working to productively integrate geo-location sensing, multimedia communication, information visualization and web 2.0 mashup technologies to create and implement these science learning activities through the use of co-design methodologies with teachers, learners, technology developers, domain experts and learning scientists.

Design is a complex activity that calls for a challenging discipline of design thinking. Winograd [16] emphasizes the importance of the dual roles of designers, as they work both with the hardware and software to create artifacts with desired behavior and appropriate use of resources. In addition, the designer needs to take the perspective of the people who will live with and alongside the system, with the primary concern for their intentions, actions and experiences. What makes this user centered design different from other types of interaction like human-computer interaction is that it is concerned with the wider implications of practice beyond the design, evaluation practices, and performance of interactive computing systems.

One technique that helps with these design challenges is to actively involve and work directly with the stakeholders throughout the design process. Co-design is one such method and can be defined as a highly facilitated, team-based process in which teachers, researchers, and developers work together in defined roles to design an educational innovation [12]. The benefits of co-design are the direct involvement of stakeholders helping to ensure that the concerns and values of the users are kept in focus. The team realizes the design in one or more prototypes and evaluates the significance of each prototype for addressing an educational need. The co-design process relies on teachers' ongoing involvement with the design of educational innovations, which typically employ technology as a central support for learning and inquiry practices. Penuel and colleagues [12] point out some of the challenges in co-design that result in tension between stakeholders in workplace norms and practice combined with the time-intensive processes required. A possible solution to resolve some of these challenges is to look more closely at the start of the design process where brainstorming techniques can be used to build a common ground for the initial concepts. Brainstorming is an associative technique used to help a group of people quickly generate and organize a large number of ideas starting from a given question or problem [7].

In the following section the initial LET´S GO co-design workshop is described. In this activity brainstorming techniques were used to generate the initial mobile science collaborative ideas. The technology-supported activities are within the field of ecology education and the learning objectives and assessments are framed within an existing curriculum.

3. The Workshop

The initial 2-days workshop was conducted first in Sweden in the late fall of 2008 and it will be followed up in the United States in early 2009. We recruited 6 teachers, 3 from a science-focused high school and 3 from middle school. Three researchers, a science learning expert and software developers also participated in the workshop. The first day (a half day workshop) was centered on introductions; a description of the working methodology and a showcase of different technologies followed up by a demonstration and discussion of some new mobile and sensor technologies. In the second day (a half day workshop), we conducted the brainstorm and sketching sessions related to the design of learning scenarios using mobile science collaboratories. Being influenced by different techniques for brainstorming [9] we adopted a systematic approach where each of the 10 people quickly came up with at least 3 ideas on yellow sticky notepapers. Then, each of the ideas were presented and loosely categorized on the wall. Thereafter, each participant got three more sticky notes to vote on the three most relevant concepts to develop further. Figure 1 illustrates the brainstorm process with the different groups in action and idea generation.

Figure 1. Brainstorming images

The outcome of the activities described above resulted in the selection of the following three ideas for learning scenarios according to the following:

1) Types of Species in a Certain Area
2) Climate Change: Past, Present, & Future
3) Interactive Field Book

Based on these selections, we divided the group into 3 sub-groups. The responsibility of each sub-group was to further develop these concepts based on a set of criteria presented in table 1. These criteria were selected after a general discussion including all participants and it served to guide the further development of the 3 concepts mentioned above. Table 1 additionally contains the Types of Species in a Certain Area scenario detailed into the concept template.

Concept Template: Local Species			
Time of Activity:	2 hours at the field stations		
	6 groups of 4 students		
Location:	10 minute walk from		
Prior Knowledge Needed:	Soil Composition and testing procedures for PH		
Prior Measurements / Data Needed:	Coordination and navigation to locations via maps		
Learning Goals	Causalities of the environment		
	Reasoning Skills		
	Grouping rationale, Roles, and Structure		
	Collective	**Small Group**	**Individual**
	discovery & explorative	predictions	verify hypothesis
Activity Type:			
	Inquiry-Based Learning		
	Hypothesis, Information, Data		
Resources Needed:	Mobile Phone+GPS, Sensors, camera,		
Outcomes:	Number of Species, mapped to the		
	Determine comparison issues		
	Scientific reports		
Success Goals:	Understanding of scientific methods		
	Species Identification & link to soil		

Table 1. Concept table for further idea development

4. Outcomes

The evolution and further development of the three initial ideas using the above structure have provided a starting point for continuing our design processes. Each of the teams has developed one of the scenarios based on the concept template that included the prior knowledge and methods and data that will be explored by the different groups of students. Locations have been generalized but are specific to each of the scenarios; for example the field location for species morphology, different areas for investigating climate change, and a location for the flora interactive field book. The types of activities and the learning goals based on the curriculum have been presented along with individual, group, and collective learning aims for each of the scenarios. Different types of resources were discussed in terms of the technological needs and other types were intentionally kept vague to allow further concept development to happen in a less predetermined way. We sought with this design to insure that we could further develop the overall concepts without putting too much focus on technical limitations or specific domains. We also discussed the intended outcomes (in terms of learning and processes) for the students and the teachers along with the basic success goals. Figure 2 illustrates a photograph that describes a specific scenario generated by one of the groups in the workshop and the scenario 1 is additionally detailed in table 1.

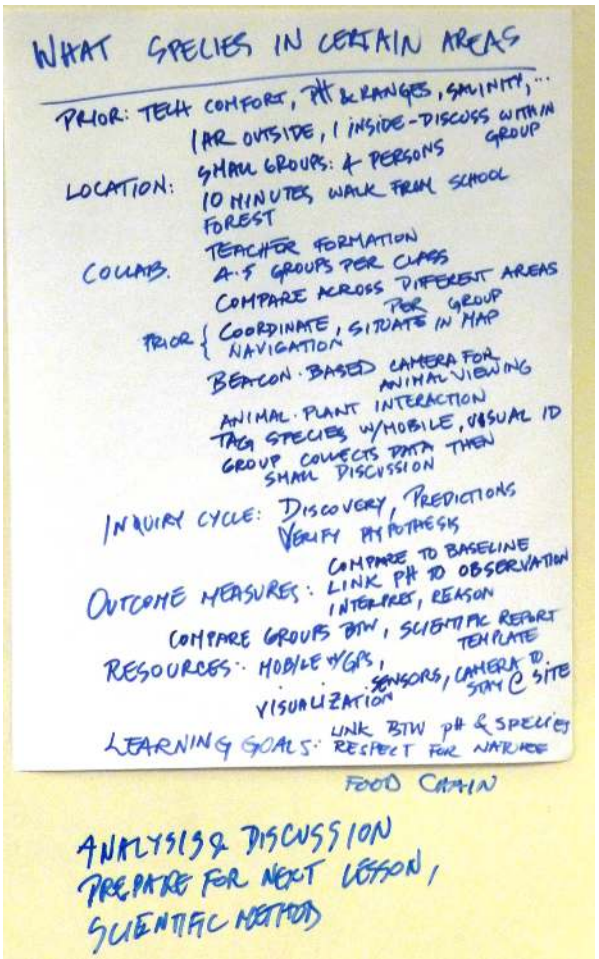

Figure 2. Group work for the Interactive Biology Notebook.

In order to evaluate and capture the dynamics of the brainstorming and sketching sessions we documented the workshop with video, photographs, and a follow up audio structured interview with each one of the participants. From the initial analysis based on the interviews, it can be mentioned that in general the brainstorming process was perceived as a useful design tool and the teachers appreciated having a chance to work with the design of new learning activities. The need of having more time for thinking and reflecting was an important aspect mentioned by most teachers. The anticipation of the next workshop to further develop the ideas was noted in all the interviews as an additional important issue. Some of the teachers also pointed out the need to involve students at a later point into the initial design process. From these initial scenarios a simple functional list was created that provides some basic ideas for the application and use of software engineering techniques such as UML diagrams and functional requirements [1] that can guide the design of the required system architecture for the implementation of mobile science collaboratories. Table 2 presents these basic functional requirements

	Resources	Interactive Biology Notebook	Global Climate Change	Local Species
Design Requirements				
	provide sensor network	soil data	weather and other enviromental	remote cameras, speicies tags
	provide live mapping tools		mobile sensors	mobile sensors
	provide data visualization tools	Graphing and other data	graphing, images	graphing, images
	provide collaboration tools	individual, group, collective	individual, group, collective	individual, group, collective
	Learning resources	local	local and global data	local data
Software Design Requirement				
	usability			
	low cost			
	open standards			
	multiple application support			
	support for different types and contexts for collaboration			

Table 2 Basic functional requirements.

and provides a catalyst that pushes our existing set of technological tools a step forward [14]. At the same time, these needs provide a level of abstraction that will allow concepts to progress toward technical developments.

5. Discussion & Next Steps

The next co-design workshop of this kind is scheduled to take place in early 2009 in the United States. We plan to follow the same process for developing more concepts and collecting additional design ideas. The larger questions remains of how to insure that the co-design process results in tools for the design and implementation of mobile science collaboratories for open-inquiry based learning that can be used integrally in K-12 educational settings. Valvoula and Sharples [15] propose the use of future technology workshops (FTW) a method for developing radically new or disruptive technology through envisioning how people might learn, work, or play collaboratively in a future of pervasive computing. These types of workshops will provide us with alternative ways to sketch out the ideas generated in the prior brainstorms by letting the teams envision the future from a socio-technical perspective and hopefully provide innovative results. Although these methods are highly participatory in nature, it is important to highlight the importance of the iterative cycle of design where relevant expertise needs to be applied across the concepts by designers, researchers, and domain experts before being refined and reinvented by the team. Sketching the user experience through different participatory methods and interaction design can provide opportunities to support such group work. Furthermore, it can add a more specialized role for the designer to participate in allowing greater integration of user experience design into the process of technology development.

Acknowledgements

The project is partially funded by Wallenberg Global Learning Network, Intel Research, & the National Geographic Society.

References

[1] Bass, L., P. Clements, et al. (2003). "Software architecture in practice." *SEI series in software engineering 2nd*. from http://proquest.safaribooksonline.com/?xmlId=0-321-15495-9

[2] Kali, Y., Linn, M.C., & Roseman, J. E. (Eds.). (2008). *Designing coherent science education.* New York: Teachers College Press.

[3] Christensen, C. M., M. B. Horn, et al. (2008). *Disrupting class: how disruptive innovation will change the way the world learns*. New York, McGraw-Hill.

[4] Soloway, E., W. Grant, R. Tinker, J. Roschelle, M. Resnick, R. Berg, M. Eisenberg (1999, August) "Science in the palms of their hands." *Comm. ACM, 42* (8), 21–26.

[5] Tinker, R.F., J.S. Krajcik (Eds.). (2002). *Portable technologies: Science learning in context.* New York: Kluwer Academic/Plenum Press.

[6] Klopfer, E., J. Perry, et al. (2005). Collaborative learning through augmented reality role playing. *Proceedings of the 2005 conference on Computer support for collaborative learning: learning 2005: the next 10 years.* Taipei, Taiwan: International Society of the Learning Sciences.

[7] Löwgren, J., E. Stolterman (2005). *Thoughtful interaction design: a design perspective on information technology.* Cambridge, MA. MIT Press.

[8] Design Based Research Collective. (2003). "Design-based research: An emerging paradigm for educational inquiry." *Educational Researcher,* 32(1), 5–8.

[9] Pahl, G., W. Beitz, et al. (1996). *Engineering design: a systematic approach*. Berlin, Springer.

[10] Rogers, Y., S. Price, C. Randell, D.S. Fraser, M. Weal & G. Fitzpatrick (2005). "Ubi-learning Integrates indoor and outdoor experiences." *Comm. ACM*, 48(1), 55-59.

[11] Scanlon, E., A. Jones, J. Waycott (2005). "Mobile technologies: prospects for their use in learning in informal science settings." Journal of Interactive Media in Education 2005(25). [jime.open.ac.uk/2005/25].

[12] Penuel, W. R., J. Roschelle, et al. (2007). "Designing formative assessment software with teachers: An analysis of the co-design process." *Research and Practice in Technology Enhanced Learning* 2(2): 51-74.

[13] Sawyer, R. K. (2006). *The Cambridge handbook of the learning sciences*. Cambridge, Cambridge University Press.

[14] Spikol, D., M. Milrad, et al. (2008). *Mobile Collaboration Tools and Systems to Support Ubiquitous Learning*. Proceedings of the Fourth Annual Conference on Collaboration Technologies 2008, Wakayama, Japan.

[15] Vavoula, G., M. Sharples (2007). "Future technology workshop: A collaborative method for the design of new learning technologies and activities." *International Journal of Computer-Supported Collaborative Learning* **2**(4): 393-419.

[16] Winograd, T. (2006). "Designing a new foundation for design." *Communications of the ACM* 49(5): 71-73.

[17] Rogers, Y., S. Price (2006). "Using Ubiquitous Computing to Extend and Enhance Learning Experiences." In M. van´t Hooft & K. Swan (Eds.). *Ubiquitous Computing in Education: Invisible Technology, Visible Impact.* Mahwah, NJ: Erlbaum Associates.

[18] Cobb, P., J. Confrey, A.diSessa, R. Lehrer, L. Schauble (2003). "Design experiments in education research." *Educational Researcher*, 32 (1), 9-13.